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Columbus, Ohio.

GEOLOGICAL SURVEY OF OHIO

EDWARD ORTON, Jr., State Geologist.

FOURTH SERIES, BULLETIN NO. 1.

THE OCCURRENCE AND EXPLOITATION OF PETROLEUM AND NATURAL GAS IN OHIO,

BY

JOHN ADAMS BOWNOCKER, D. SC.,

Professor of Inorganic Geology, Ohio State University.

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Published by authority of the Legislature of Ohio, under the supervision of the State Geologist.

COLUMBUS, OHIO, DECEMBER, 1903.

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LETTER OF TRANSMITTAL.

To His Excellency, George K. Nash, Governor of Ohio.

Sir:—I have the honor to present herewith my first report as State Geologist. Aside from the preparatory matter dealing with the present organization of the survey, its plans, and the work in progress, it consists of a treatise on The Occurrence and Exploitation of Petroleum and Natural Gas in Ohio.

This topic has been previously carefully studied by the survey and elaborate reports were issued upon it in 1886, 1888 and 1890, presenting the facts then known. During the next ten years the industry continued to make rapid progress in extent and value of output. No further investigations were authorized until 1900, when the legislature again made appropriations for the work of the Geological Survey. This topic was considered as among the most urgent of all those presenting themselves for attention, and it was at once determined to bring the records of the discoveries and production of oil and gas down to date, while the facts were still available.

Accordingly, in June 1900, I appointed Professor John Adams Bownocker, of the Ohio State University, to take up the study of this subject, and he has pursued the same with great energy during the past three years. I submit the results of his labors with confidence that they will not only be found of great economic and scientific value at present, but also that their value will become increasingly apparent as time goes on. There seems good ground for believing that the supply of oil and gas is shortlived. It was discovered but a few decades ago, yet we have already witnessed the rapid exhaustion of many important fields. It becomes doubly important, therefore, that we shall preserve while we can the most complete and detailed records of its discovery and use. It is believed that the present report, in connection with those before issued, will accomplish these ends with credit to the state.

Very respectfully submitted,

Edward Orton, Jr,
State Geologist.

Ohio State University.
December 1903.

OFFICERS OF THE SURVEY.

EDWARD ORTON, JR., E. M..... State Geologist
Economic Work in Cement and Clay Industries.

CHARLES SMITH PROSSER, M. Sc.....Assistant Geologist
Areal and Stratigraphical Geology.

JOHN ADAMS BOWNOCKER, D. Sc..... Assistant Geologist
Economic Work in Oil, Gas, Salt and Coal.

NATHANIEL WRIGHT LORD, E. M.....Consulting Chemist
Economic Work on Constitution and Utilization of Coals.

ALBERT VICTOR BLEININGER, B. Sc.....Special Assistant
Technological Work in Cement Manufacture.

SAMUEL VERNON PEPPEL, B. Sc.....Special Assistant
Technological Work in Lime and Sand Brick Industries.

FRANK HARVEY ENO, C. E.....Special Assistant
Utilization of Portland Cement.

MARION W. MUMMA, B. Sc.....Assistant
Assistant in Mapping Trenton Limestone Oil and Gas Fields.

METTA L. SEYMOUR..... Stenographer and Clerk

THE ORGANIZATION AND WORK OF THE GEOLOGICAL SURVEY OF OHIO.

By PROF. EDWARD ORTON, Jr., STATE GEOLOGIST.

In issuing this bulletin, the first of a new series, it is proper and seasonable to set forth in brief the relation of the work here presented with that which has been done by the organization in previous years, and to state what plans for the future are now being entertained.

HISTORICAL.

The last work done by the survey under the administration of Dr. Edward Orton, was embodied in Volume VII, published in 1893. In that volume, the preface, amounting to 11 pages, was devoted to a historical review of the work accomplished up to that time by the First, Second and Third organizations of the Geological Survey of Ohio. It is there shown that in Volume VII, the last outstanding tasks were completed, the last unpublished manuscript collected, the promises made during preceding administrations fulfilled, and that the volume thus brought to a natural conclusion the work which had been carried on for so many years.

During the succeeding six years, the work of the survey stood in abeyance. Dr. Orton still held the appointment of State Geologist, but the position was largely honorary as no appropriations were made to support the office in any way. Correspondence involving geological questions was answered and occasional visits were made to different points to give advice regarding local geological problems, but this work was done voluntarily and at private expense.

After Dr. Orton's death in October, 1899, and the appointment of the present incumbent, the question of again taking up active work was considered. The salient points of the geology of the state had been well worked out by the preceding organizations, and the economic side of the question had been considered at much length. But neither science nor industry stand still, and in the decade or more which had passed since most of the work had been done, great changes had occurred. These changes were principally in the interpretation placed upon the observed facts, rather than in the facts themselves. Some extensions had been made to discoveries formerly left incomplete, but in the main, the valid reason for again beginning work was to study anew the structure of the state and its mineral wealth from the point of view now prevailing. Further, while the people already had a good knowledge of the mineral resources of the state as to location and area, it was felt that much future work might profitably be directed towards increasing their knowledge of how to use them wisely.

Having reached the conclusion that a sufficient interval since the work of the preceding survey had elapsed to make a reconsideration of the subject not only profitable but even urgent in certain directions, the question of ways and means arose. On investigation, the law under which the last work had been done by the survey in 1892-93 was found to have been passed in 1889. For information, the law is reprinted here in full:

Laws of Ohio, 1889, 86. p. 262.
(Senate Bill 409.)

AN ACT

To Provide for the Extension of the Geological Survey of the State.

Section 1. Be it enacted by the General Assembly of the State of Ohio, That the governor is hereby authorized to appoint a state geologist, whose duty it shall be to continue and extend the investigations already made into the geological structure and resources of the state. Said state geologist shall be appointed for a term of three years, but he may be removed for cause at any time, and a successor appointed in his stead; and the governor is authorized to fill any vacancy which may occur from any cause, at any time. The compensation of said state geologist shall be at the rate of two hundred dollars per month, for the time actually employed; and said geologist shall have power to employ such assistants as he may need; but in no event shall the salary of the geologist, pay of assistants, and expense of the department, exceed the amount of the expenditure authorized by the general assembly.

Section 2. It shall be the duty of said geologist to study, and determine as nearly as possible, the number and extent of the various formations of the state; to represent to same, from time to time, upon properly constructed maps and diagrams; to study the modes of occurrence and the distribution of the useful minerals and products of these formations; to determine the chemical composition and structure of the same; to investigate the soils and water supply of the state; and to give attention to the discoveries of coal, building stone, natural cement, petroleum, gas and other natural substances of use and value to the state. He may also collect and describe the fossils of the various geological formations of the state; but no expenditure shall be incurred under this head that is not expressly ordered and provided for by the general assembly.

Section 3. The said geologist shall make, on or before the first day in February of each year, a report to the governor, covering the work of the preceding year, and the report shall be transmitted to the general assembly, to be printed in the same manner as other public documents, or as shall be otherwise ordered.

Section 4. The salaries of the state geologist, and the assistants employed by him, together with the traveling and incidental expenses, shall be paid monthly, on presentation of properly itemized vouchers, signed by the governor, out of the state treasury, from the appropriation made for such purpose.

Section 5. There is hereby appropriated from the general revenue fund the sum of one thousand dollars, annually, for the purpose above named.

Section 6. This act shall take effect and be in force from and after its passage.

NOAH H. ALBAUGH,
Speaker pro tem. of House of Representatives.

THEODORE F. DAVIS,
President pro tem. of the Senate.

Passed April 12, 1889.

From the terms of the law, it was evidently intended to provide for the creation of a bureau of geology for the service and advantage of the state, but that only a portion of the time of the State Geologist should be applied to this purpose, as the annual appropriation made was much too small to provide the salary of the State Geologist continuously, without making any provisions for office expenses, assistance, etc. It was thought that a few months work per year would be sufficient to maintain the survey abreast of geological developments.

The powers and duties of the State Geologist under this act were so broad and general as to permit carrying on any work then in contemplation, or likely to arise in the future, so that no new legal provision was thought necessary in connection with re-opening the work of the survey. The sum designated in Section 5, was not made a limiting condition of the law, so that the legislature may appropriate any other amount, at its discretion, for carrying on the work.

Accordingly, the matter was brought before the Seventy-fourth General Assembly and an appropriation of $2,500.00 for the year 1900, and $3,500.00 for the year 1901 was asked and granted and the Seventy-fifth General Assembly in their term appropriated $5,000.00 and $3,000.00 respectively for 1902 and 1903.

OFFICIAL INVESTIGATIONS NOW IN PROGRESS.

The work of organizing the survey, and deciding upon the studies to be made first was at once taken up. The following subjects were selected and men engaged to study and report upon them:

FIRST. THE AREAL AND STRATIGRAPHICAL GEOLOGY OF OHIO.

The elaborate work done upon this topic in the seventies, and published in Volumes I, II and III, of the Survey Reports, was excellent at the time, but now needs revision. The work from 1882 to 1894 being economic, stratigraphical questions were only studied so far as necessary to tracing and classifying mineral deposits, so that the strata of Ohio were not classified according to the now accepted schemes, nor correlated with those of surrounding states, except where economic work made practical correlation necessary. Geologists from the United States Geological Survey, and from other states, were being sent into Ohio in order to find what light the rocks of this state would shed upon mooted points in stratigraphical work elsewhere.

Considerations of state pride as well as scientific enthusiasm both urged that this state should carry its own burdens and do its share in furthering researches into these purely scientific aspects of geology. Accordingly a small sum of money was set aside for this purpose and Mr. Charles S. Prosser, M. Sc., Professor of Geology in the Ohio State University, was appointed Assistant Geologist in charge of this topic.

Professor Prosser was unable to at once begin on Ohio work, as he had at the time unfinished researches in Kansas, Maryland and New York to complete and report upon for the United States Geological Survey or state surveys. But a beginning was made in 1900, and as these other tasks have from time to time been concluded, an increasing share of his time has been devoted to Ohio work, until it now receives almost the entire time he has available from University duties. Professor Prosser has published, by permission, in advance of the formal survey reports, the results of some portions of his work in Ohio, in the current Geological journals, and his work has received favorable comment from those best able to criticise it. It is the intention to continue, as means are available, to spend modest sums annually on this work as long as may be needed, and to continue this method of publication until sufficient matter is ready to compose a bulletin of suitable size, which will then appear in its place in the series.

SECOND. THE OCCURRENCE AND EXPLOITATION OF PETROLEUM AND NATURAL GAS IN OHIO.

This topic, for reasons set forth in the letter of transmittal of this volume, seemed to require attention more urgently than any other. It was assigned to Mr. John A. Bownocker, D. Sc., Professor of Geology in the Ohio State University, who was appointed Assistant Geologist. The result of three years labors in this field are presented in this Volume.

THIRD. THE PORTLAND CEMENT INDUSTRY OF OHIO.

This topic represents most fairly the central idea which actuates the present management of the survey. The limestones, the lime industry and the cement industry have all been written upon in the earlier reports. But, the point of view has so wholly changed during the 15 or 20 years since elapsed, that they fail to point out to the people of the state the value of their resources, or the possible strength of their position as a cement producing state. This rising industry only needs a little safe counsel and guidance to find a very large and important development in Ohio, and it seems that the Geological Survey is of all bureaus the one best fitted to do this service for the people.

Three phases of the subject have been considered.

1*st. Resources of Ohio in the Raw Material for Cement Manufacture.*—This includes a study of the limestones and marls, clays, sands, etc., viewed from the standpoint of cement manufacture. The researches for this chapter have been largely made, and it only remains to write the report. Special Assistant, Samuel V. Peppel, B. Sc., has done the bulk of the work in this subject, has collected most of the samples in the field, analysed them in the laboratory, and prepared text covering a considerable part of the state. The general responsibility of the chapter will fall upon Prof. Edward Orton, Jr., who will put it into final shape for publication.

2nd. The Technology of Cement Manufacture.—This branch of the subject, involving the important question of manufacture and storage, was given to Special Assistant Albert V. Bleninger, B. Sc., Instructor in Ceramics in the Ohio State University. His work has been unremitting, and has included not only an exhaustive study of the literature of the subject, mostly in German, and a careful study of the most important cement plants of the United States, but also an immense amount of synthetic experimental work.

Permission to publish articles involving a preliminary account of these researches has been given, and has appeared in the Transactions of the American Ceramic Society, Vols. IV and V. The official report is now nearly completed.

3rd. The Utilization of Cement.—This chapter was assigned to Professor C. Newton Brown, C. E., Dean of the College of Engineering of the Ohio State University. Prof. Brown had barely begun work when taken suddenly ill, his death occurring shortly after in March, 1902. The matter stood in abeyance for some months, when Special Assistant Frank H. Eno, C. E., Associate Professor of Civil Engineering in the Ohio State University, was secured to take up the work. He has given it elaborate study, has seen the notable cement industries of the United States and is well qualified by experience and ability to give a clear and valuable discussion of how to use cements advantageously. These uses are but just beginning, and the public is but little aware of the expansion soon to come. The text of this article is also well under way.

These three topics were designed, originally, as chapters to collectively, form a book; in order to avoid unnecessary loss of time, they will probably be issued as separate bulletins, and will be published during the early part of 1904.

FOURTH. THE LIME INDUSTRY OF OHIO.

This work was taken up in connection with the preceding bulletin on cement, as the latter involved a study of the lime resources of the state. But, as much of the lime in Ohio is unfit for cement manufacture, and is highly valuable for other purposes, it was thought best to collect data for both bulletins at once, as it could be done with but little extra expense.

Also, the technology of lime burning and use had never been adequately studied, and an effort was made to present the facts in this connection with some considerable completeness. Special Assistant, Samuel V. Peppel, B. Sc., was given charge of this topic in connection with his collection of data for the cement resources, and has carried it out with much energy and enthusiasm. His completed report now awaits publication.

FIFTH. THE MANUFACTURE OF SAND-LIME BRICK.

This topic was taken up in connection with the researches already

being carried on in regard to lime and cement. The industry is a new one in this country, but has become well established in Germany, where upwards of one hundred plants are in successful operation. By this process, building brick of good grade are made from sand into which 5 to 10 per cent. caustic lime has been thoroughly mixed. The mixture is shaped into bricks in powerful presses, and these are hardened in an atmosphere of steam for ten hours or more at high pressure. The process invites not only the use of lime on a large scale, but also opens the way to a still larger use for sand.

Mr. Samuel V. Peppel was also placed in charge of this work and has prepared a very excellent report on the subject, which is ready for printing. Permission to publish in advance portions of this report in technical journals was given some time since, and these preliminary reports have attracted wide attention over the country.

SIXTH. THE CHEMICAL CHARACTER OF OHIO COALS AND NOTES ON THEIR PROPER UTILIZATION.

This work was undertaken by Professor Nathaniel W. Lord, E. M., Consulting Chemist of the Survey, and Professor of Metallurgy in the Ohio State University, who has done a great deal of important work along this line in other connections. The coal veins studied so far comprise the No. 4 or Clarion (Ferriferous limestone) coal of Vinton, Jackson, Gallia, and Lawrence counties, and the No. 6 or Middle Kittanning coal, which was sampled with unprecedented care at frequent intervals over its whole area between Athens and Tuscarawas counties. There yet remains the extreme northern and southern extensions of the No. 6 coal to be sampled, but the work now done covers the main productive area. These researches are directed towards establishing the chemical unity of real coal-matter of any particular vein, as distinguished from its accidental or accessory ash-forming ingredients, and also the sharp distinction between the real coal-matter of different veins, as evidenced by the composition, calorific power, etc. His work also includes a study of the occurrence of sulphur in coals, and to what extent it may be reduced by treatment.

Preliminary reports on part of this work have been published, by permission, in the Engineering press. It is expected that a considerable portion of the report will be printed in the near future, but the completion of the work for all the coals of the state is a distant matter.

SEVENTH. THE SALT INDUSTRY OF OHIO.

This subject was taken up by Assistant Geologist Bownocker during the summer of 1903. The discovery and utilization of the rock salts of northern Ohio has all been subsequent to the report by W. J. Root in 1888, and the development of a growing soda ash industry on this foundation is the immediate occasion for taking it up at this time. Ohio with her stores

of lime, sand and fuel, has only needed soda to become a great center of the glass industry. This supply has now become a possibility. The report on this topic is nearing completion.

EIGHTH. THE PITTSBURGH COAL IN HARRISON, AND THE MEIGS CREEK COAL IN HARRISON, JEFFERSON AND BELMONT COUNTIES.

Almost the only coal areas left unmapped in the work of the previous survey are those veins found in the high broken land of southeastern Ohio. The recent sudden increase in interest in the thin veins of coal away from present railroad communication has led to a very considerable demand for information about this district. The topographic work of the United States Geological Survey which is being done in collaboration with the State of Ohio, has been practically completed in the area covered by these coals, and it is expected that the work will be greatly assisted by the new maps. Assistant Geologist Bownocker has this work in hand, but the report will not be completed without another season's field work. This concludes the list of topics upon which formal reports have been authorized.

THE SURVEY IN ITS RELATIONS TO THE PUBLIC.

The usefulness of the survey is not limited to the preparation of formal reports on important topics. There is a constant and insistent desire on the part of the people to use it as a technical bureau for free advice in all matters affecting the geology or mineral industries of the state. A very considerable correspondence comes in, increasing rather than decreasing in amount, and asking specific and particular questions on points in local geology.

The volume of this correspondence has made it necessary to adopt a uniform method of dealing with these requests. Not all of them can be granted, but some can and should be answered. There is a certain element of justice in the people demanding such information, from the fact that the geological reports issued in former years were not so distributed as to make them accessible to the average man or community today. The cases commonly covered by correspondence may be classified as follows:

1*st. Requests for information covered by previous publications.*—This is furnished where the time required for copying the answer is not too large. Where the portion desired cannot be copied, the enquirer is told in what volume and page it occurs and advised how to proceed to get access to a copy of the report.

2*nd. Requests for identification of minerals and fossils.*—This is done, where possible. As a rule, the minerals and fossils are simple and familiar forms, which can be answered at once. In occasional cases, a critical knowledge is required and time for investigation is necessary. Each assistant is expected to co-operate with the State Geologist in answering inquiries concerning his field.

3rd. Requests from private individuals for analyses of minerals and ores, and tests to establish their commercial value.—Such requests are frequent. They cannot be granted, however, except in rare instances. Such work should be sent to a commercial chemical laboratory. The position has been taken that the Geological Survey is in no sense a chemical laboratory and testing station, to which the people may turn for free analytical work. Whatever work of this sort is done, is done on the initiative of the survey and not at the solicitation of an interested party.

The greatest misapprehension in the public mind regarding the survey is on this point. Requests for state aid in determining the value of private mineral resources, ranging from an assay worth a dollar, up to drilling a test well costing several thousand dollars, represent extreme cases. At present there is no warrant for the survey making private tests, even where the applicant is entirely willing to pay for the service. In many cases individuals would prefer the report of a state chemist or State Geologist to that of any private expert, at equal cost, because of the prestige which such a report would carry. But it is a matter of doubt whether it will ever be the function of the survey to enter into commercial work of this character; it certainly will not be unless explicit legal provisions for it are made.

4th. Requests from a number of persons representing a diversity of interests, who jointly ask the Survey to examine into and publicly report upon some matter of local public concern.—Such cases are not common. It is not always easy to determine whether such propositions are really actuated by public interest or not. Each case must be judged on its merits. The Survey will often be prevented from taking up such investigations by the lack of available funds, while otherwise the work would be attempted.

The reputed discovery of gold is one of the most prolific sources of such calls for state examination. It usually seems wise and proper to spend a small sum in preventing an unfounded rumor from gaining acceptance in the public mind, before it leads to large losses, and unnecessary excitement. The duty of dispelling illusions of this sort cannot be considered an agreeable part of the work of the survey, but it is nevertheless of very direct benefit to the people of the state.

FORMER PUBLICATIONS OF THE SURVEY.

The work performed by the First, Second and Third organizations of the Geological Survey of Ohio is comprehended in the following list of publications:

FIRST GEOLOGICAL SURVEY 1837-1838

Title of Volume	Date of Issue	Number of Pages	Number of Copies Printed	Geologist in Charge
First Annual Report	1838	184	5,000	W. W. Mather
Second Annual Report	1838	236	5,000	W. W. Mather

SECOND GEOLOGICAL SURVEY 1869-1888

Title of Volume	Date of Issue	Number of Pages	Number of Copies Printed	Geologist in Charge
Report of Progress	1869	176	14,500	J. S. Newberry
Report of Progress	1870	568	14,500	J. S. Newberry
Report of Progress	1871	3	400	J. S. Newberry
Geology of Ohio, vol. I, part I, Geology	1872	680	20,000	J. S. Newberry
Geology of Ohio, vol. I, part II, Paleontology	1873	*401 †49	20,000	J. S. Newberry
Geology of Ohio, vol. II, part I Geology	1874	701	20,000	J. S. Newberry
Geology of Ohio, vol. II, part II, Paleontology	1875	*431 †59	20,000	J. S. Newberry
Geology of Ohio, vol. III, Geology	1878	958	20,000	J. S. Newberry
Geological Atlas of Ohio	1879		5,000	J. S. Newberry
Geology of Ohio, vol. IV, Zoology and Botany	1882	1,070	20,000	J. S. Newberry
Geology of Ohio, vol. V, Economic Geology	1884	1,124	10,000	Edward Orton
Preliminary Report on Petroleum and Inflammable Gas	1886	76	2,500	Edward Orton
Geology of Ohio, vol. VI, Economic Geology	1888	831	15,000	Edward Orton

THIRD GEOLOGICAL SURVEY 1889-1894

Title of Volume	Date of Issue	Number of Pages	Number of Copies Printed	Geologist in Charge
First Annual Report	1890	323	10,000	Edward Orton
Geology of Ohio, vol. VII, part I, Economic Geology	1893	290	2,500	Edward Orton
Geology of Ohio, vol. VII, (complete including part I)	1894	970	7,500	Edward Orton

* Pages. † Plates.

DISTRIBUTION OF FORMER REPORTS.

No copies of any of the reports of the survey published prior to 1903 are in the hands of the State Geologist available for distribution, free or otherwise. The early reports were generally distributed as soon as printed, a small number going to the State Geologist for exchanges and personal distribution, and by far the greater number being distributed pro rata among members of the General Assembly then in office. This arrangement proved very unsatisfactory as there was no fixed source of volumes to meet current demands, after the first distribution.

With Volume V and subsequent volumes a new arrangement was made, by which the number distributed to the General Assembly was reduced, and a certain part of the issue was placed in the hands of the Secretary of State for sale at the cost of publication. This arrangement proved a great advance over the preceding method, but has proven still inadequate, as is shown by the fact that each issue thus put on the market was soon sold out, * and the only method of obtaining copies soon came to be through the second-hand book-dealers of the country. These dealers have occasionally secured a small supply from public men who received them during their terms of office, but did not distribute them.

It is a matter of profound regret that there is no official source at present from which a full set of these valuable reports may be obtained by deserving applicants. Odd volumes, and occasionally full sets, can still be bought from the second-hand book dealers, who have collected them with a foresight and prudence which now yields them a handsome return.

THE PUBLICATION AND DISTRIBUTION OF FUTURE REPORTS.

Owing to the unfortunate situation in regard to the publications of the First, Second and Third organizations of the Geological Survey, it has been thought wise to designate the present series as the Fourth. There has been no legal enactment conferring a new title on the present organization of the survey, and as already explained, the work is being done under the law of 1889, which marks the end of the second and the beginning of the third organizations. But a law has recently been enacted prescribing the method of publication and distribution of the reports of the State Geologist, which departs so far from the plans previously adopted that it makes such a differentiation in title of the bulletins necessary to the convenience of those who are to distribute and have charge of the future publications of the survey.

The text of the law is given herewith, as a matter of information to those interested.

*A few copies of Vol. VII only are now left in the office of the Secretary of State

Laws of Ohio, 1902, Vol. 95, p. 593.
(House Bill No. 800.)

AN ACT

To Provide for the Publication and Distribution of the Reports of the State Geologist.

Section 1. Be it enacted by the general assembly of the state of Ohio, that whenever the state geologist shall have completed a bulletin upon any of the subjects upon which he is authorized to conduct investigation, he shall notify the state printing commission of this fact, and it shall be the duty of this commission to determine the number of copies which shall be printed, and the grade of paper, the kind of binding, and any other details incident to its proper publication.

Section 2. It shall be the duty of said commission to provide for the publication of said bulletin as soon as possible after the completion of the same. The issue shall consist of a minimum number of three thousand copies.

Of these, one thousand copies, after deducting 200 for the State Library, shall be distributed pro rata among the general assembly.

One thousand shall be distributed free by the state geologist in exchange with other surveys, and with individuals whose services have been used in collection or preparation of the matter for the bulletins. Of this number not more than four hundred may be distributed during the first year after publication, and not more than fifty in any subsequent year.

One thousand copies shall be set aside for binding with other bulletins from time to time, when a sufficient number of such bulletins have accumulated to make collectively a volume of from 800 to 1,000 pages. They shall be bound, lettered and numbered, to take their place in the series of volumes already published by the survey.

The distribution of the bound volume of the survey shall be in the hands of the state geologist; but the state library shall receive ten copies, each member of the general assembly one copy, with privilege to draw not to exceed two other copies on application, and public libraries in the state shall be supplied with one copy each. The volumes remaining after these demands have been met, may be distributed among the geological surveys and geological societies of the United States and of foreign countries, in exchange for their publications.

Section 3. The board may, at its discretion, order the publication of extra copies in addition to the three thousand already provided for. These extra copies shall be placed in the hands of the state geologist for sale, at a price exceeding the net cost of printing and binding by 50 per cent., which price is to be established by the state supervisor of public printing. The proceeds of the sale of such copies shall be accounted for and paid into the state treasury and the state geologist may be required by the commission to give suitable bond for the security of the funds thus passing through his hands. The proceeds of such sales shall be credited to the account of the geological survey, without distinction from other funds which the general assembly may from time to time appropriate for this purpose.

Section 4. The cost of printing, illustrating, electrotyping, binding, etcetera, of said bulletins and said volumes, shall be paid from the general appropriation for state printing.

Section 5. This act shall take effect from and after its passage.

W. S. McKINNON,
Speaker of the House of Representatives.
F. B. ARCHER,
President of the Senate.

Passed, May 12, 1902.

Under the terms of this act, a number of things will be accomplished which will remedy, in large part, the weak points of the earlier systems.

(a) It provides for a minimum issue, for bulletins of small general interest, and an elastic system for increasing the issue, where bulletins promise to be of wide general interest.

(b) It provides for an adequate system of exchanges by which the credit of the state may be maintained among other states and countries which publish similar literature.

(c) It prevents the immediate distribution of all the copies of any report, and thus safeguards the needs of the future.

(d) In the case of large issues, it enables any one interested to secure a copy of any bulletin on payment of a small sum.

(e) It insures that the bulk of each issue reaches only interested persons, as copies can only be obtained by application and generally by payment. It is estimated that only a small part of the issues of the early reports ever reached appreciative hands.

(f) It provides for the publication at any time of any report which may be ready, thus making the work up-to-date and effective, instead of requiring all articles to wait until a sufficient number are ready to collectively make a volume.

(g) It is a step towards making the work self supporting.

In short, it is thought that this law will do much to place the work of the survey upon a much more effective, useful and creditable basis than ever before, and on a parity with that of other states.,

OBTAINING COPIES OF REPORTS.

To obtain copies of reports in future, applications should be addressed to the State Geologist. In those cases where application is made for a free copy, the application should be addressed to the senator or representative of the district in which the applicant lives, or if addressed to the State Geologist, should state the basis upon which the claim for a free copy is made.

The great majority of applications must be filled from the stock which is placed on sale; information as to the price of these, and the methods of making remittances which will be required, will be sent promptly in response to enquiries.

STATEMENT OF RECEIPTS AND EXPENDITURES.

For the information of the public, the following statement of receipts and disbursements has been prepared. All accounts are paid by official orders on the Auditor of State, signed by the State Geologist, and countersigned by the Governor.

RECEIPTS.

By General Appropriation Bill, for year 1900	$2,500 00
By General Appropriation Bill, for year 1901	3,500 00
By General Appropriation Bill, for year 1902	5,000 00
By General Appropriation Bill, for year 1903	3,000 00
By Sale of Gas Engine, October, 1902	90 00
Total receipts to December 1st, 1903	$14,090 00

DISBURSEMENTS.

Beginning April 28, 1900, and Ending December 4th, 1903.

Number of Warrant	Date of Issue.		Name of Person in whose favor warrant was drawn.	Purpose of Expenditure.	Amount.
	1900				
1	Apr.	28	Edward Orton, Jr.	Traveling expenses	$ 10 90
2	June	11	S. W. Collett	Photographs of quarries	10 50
3		16	Hann & Adair	Voucher books	9 27
4	July	7	F. M. Watkins	4-Horse power gasoline engine	197 25
5		7	Columbus M. & M. Supply	Belts and lacings	3 24
6	June	20	Columbus M. & M. Supply	Pipe and fittings for engine	19 62
7	July	2	Eimer & Amend	Bosworth crusher	32 00
8	June	30	Engelke & Bigelow	Freight and cartage	5 93
9		30	E. C. Kissinger	Barrel of lime	1 00
10		30	Albert V. Bleininger	One-half month's salary	30 00
11		30	R. W. Nauss	One-half month's salary	20 00
12		30	M. L. Seymour	One-half month's salary	7 50
13		30	J. A. Bownocker	One-half month's salary and traveling expenses	62 50
14	July	10	Hann & Adair	Stamped envelopes and stationery	80 35
15		10	Standard Oil Co	75 gallons gasoline	6 00
16		1	Edward Orton, Jr.	Salary and traveling expenses.	54 75
17		31	J. A. Bownocker	One month's salary and traveling expenses	125 00
18	Aug.	1	A. V. Bleininger	One month's salary	60 00
19	July	31	R. W. Nauss	One month's salary	40 00
20		31	M. L. Seymour	One month's salary	15 00
21		31	Alma Portland Cement Co.	Six barrels ground limestone	6 00
22	Aug.	12	Standard Oil Co	Ten gallons kerosene oil	75
23	Aug.	13	Eimer & Amend	Instruments	3 65
24	July	21	J. Croft Beard	Lettering sign	2 50
25		27	Edward Orton, Jr	One month's salary and traveling expenses	135 42
26		12	Queen & Co	Repairing barometers	7 55
27	Sept.	1	M. L. Seymour	One month's salary	15 00
28		1	A. V. Bleininger	One month's salary and traveling expenses	71 96
29		1	R. W. Nauss	One month's salary	40 00
30		1	J. A. Bownocker	One month's salary and traveling expenses	125 00
31		1	F. J. Talbot	Gasoline	1 20
32		26	J. A. Bownocker	One-fourth month's salary and traveling expenses	62 20

DISBURSEMENTS—Continued.

Number of Warrant	Date of Issue.		Name of Person in whose favor warrant was drawn.	Purpose of Expenditure.	Amount.
	1900				
33	Sept.	27	Chas. S. Prosser	Salary and traveling expenses	$ 102 21
34	Oct.	5	M. L. Seymour	One month's salary	20 00
35		5	R. W. Nauss	One month's salary	45 00
36		5	A. V. Bleininger	One-half month's salary	30 00
37		5	Engelke & Bigelow	Freight and cartage	27 38
38		5	Ohio Furniture Co	Office furniture	9 50
39		5	C. H. Woodruff	Repairs in Chemical Laborat'y	2 55
40		8	McAllister, Mohler & Co.	Office furniture	109 20
41		20	Fred Charles	Cartage	2 00
42		20	Columbus M. & M. Supply Co	Mill supplies	2 50
43		20	Standard Oil Co	Coal oil and gasoline	6 90
44	Nov.	2	R. W. Nauss	One month's salary	45 00
45		1	M. L. Seymour	One month's salary	20 00
46		3	W. L. Lillie & Co	Office furniture	3 00
47	Dec.	10	Edward Orton, Jr	Cash advanced for labor	11 05
48	Nov.	19	C. H. Woodruff	Office furniture	49 00
49	Dec.	1	R. W. Nauss	One month's salary	45 00
50		10	M. L. Seymour	One month's salary	20 00
51		31	William Cannan	Sampling limestones	3 50
52		31	M. L. Seymour	One month's salary	20 00
53		31	R. W. Nauss	One month's salary	45 00
	1901				
54	Feb.	9	M. L. Seymour	One month's salary	20 00
55	Mch.	1	N. W. Lord	Investigation on Clarion coal	100 00
56		1	M. L. Seymour	One month's salary	20 00
57	Apr.	1	Chas. S. Prosser	Salary and expense account	18 85
58		1	F. M. Higgs	Office furniture	5 00
59		1	M. L. Seymour	One month's salary	20 00
60		1	W. B. Clark	Book	2 00
61		1	Chemical Store Room	Chemical supplies	33 94
62		1	P. Hayden Foundry Co	Castings for cement kiln	3 96
63	May	1	M. L. Seymour	One month's salary	20 00
64		2	Edward Orton, Jr	Cash advanced for labor	6 57
65		2	Engelke & Bigelow	Freight and cartage	2 12
66		2	D. C. Beggs Co	Office furniture	38 00
67	June	1	M. L. Seymour	One month's salary	20 00
68	July	2	M. L. Seymour	One month's salary	20 00
69		2	J. A. Bownocker	One month's salary and traveling expenses	125 00
70		2	Chas. S. Prosser	Traveling expenses	47 28
71		2	Champlin Printing Co	Printing certificates	2 75
72		2	Hann & Adair	Printing circulars	2 40
73		2	A. V. Bleininger	One month's salary and traveling expenses	150 00
74		2	Edward Orton, Jr	One month's salary and traveling expenses	250 00
75		20	S. V. Peppel	One month's salary and traveling expenses	150 00
76		20	A. V. Bleininger	One month's salary and traveling expenses	150 00
77		20	J. A. Bownocker	One month's salary and traveling expenses	125 00
78		20	Chas. S. Prosser	Salary nine days	36 00
79		31	M. L. Seymour	One month's salary	20 00

DISBURSEMENTS—Continued.

Number of Warrant.	Date of Issue.	Name of Person in whose favor warrant was drawn.	Purpose of Expenditure.	Amount.
	1901			
80	July 20	T. J. O'Neil	Two canvas sampling sheets	$ 4 50
81	20	Hann & Adair	Printing tags	2 50
82	20	Cherington Printing & Engraving Co.	Official seal	6 50
83	20	Orr, Brown & Price	Three gross sample bottles	6 96
84	Aug. 26	A. V. Bleininger	One month's salary and traveling expenses	150 00
85	26	Chas. S. Prosser	Salary	108 00
86	26	R. W. Nauss	Sampling limestone	40 00
87	26	M. L. Seymour	One month's salary	20 00
88	26	S. V. Peppel	One month's salary and traveling expenses	150 00
89	26	Edward Orton, Jr	Salary and traveling expenses	100 00
90	Sept. 2	Engelke & Bigelow	Freight and cartage	31 96
91	2	Tallmadge Hdw. Co	Sampling tools	1 65
93	2	Rood Lumber Co	Fifty boxes for samples	7 50
94	2	Edward Orton, Jr.	For cash advanced for labor	37 90
95	2	Standard Oil Co	Gasoline	5 00
96	25	J. A. Bownocker	Two months' salary and traveling expenses	200 75
97	30	Chas. S. Prosser	Salary and traveling expenses	237 92
98	30	M. L. Seymour	One month's salary	20 00
99	30	S. V. Peppel	One month's salary and traveling expenses	150 00
100	30	Engelke & Bigelow	Freight and cartage	10 54
101	30	Jones, Witter & Co	Seventy-five sample sacks	10 50
102	30	McClelland & Co	Note books and stationery	9 50
103	Oct. 7	E. E. Somermeir	Salary and traveling expenses	26 80
104	19	R. W. Nauss	One month's salary	20 00
105	31	M. L. Seymour	One month's salary	20 00
106	31	S. V. Peppel	One month's salary	100 00
107	31	Engelke & Bigelow	Freight and cartage	9 23
108	31	Rood Lumber Co	Fifty boxes for samples	7 50
109	31	T. J. O'Neil	One canvas sampling sheet	2 25
110	Dec. 2	S. V. Peppel	Traveling expenses 2 months, one month's salary	275 03
111	1	Westinghouse Co	One air pump	50 00
112	1	Engelke & Bigelow	Freight and cartage	5 74
113	1	Edward Orton, Jr.	For cash advanced F. N. Huddleson for sampling	25 00
114	1	M. L. Seymour	One month's salary	20 00
	1902			
115	Jan. 2	M. L. Seymour	One month's salary	20 00
116	2	S. V. Peppel	One month's salary	100 00
117	2	Edward Orton, Jr.	For cash advanced Mr. F. N. Huddleson for sampling	20 00
118	3	R. W. Nauss	Labor sampling limestone	9 75
119	3	F. N. Huddleson	Sampling limestone	9 25
120	13	Geo. R. Rose	Air blast apparatus	14 54
121	13	Hann & Adair	500 stamped envelopes	11 35
122	Feb. 13	Central Ohio Paper Co.	2 dozen stenographer's tablets	1 80
123	Jan. 13	Tallmadge Hdw. Co	Tools	75
124	14	R. W. Nauss	Sampling limestone	5 25
125	18	Chas. S. Prosser	Traveling expenses	26 30
126	Feb. 6	F. N. Huddleson	Sampling limestones	17 00

DISBURSEMENTS—Continued.

Number of Warrant.	Date of Issue.	Name of Person in whose favor warrant was drawn.	Purpose of Expenditure.	Amount.
	1902			
127	Feb. 6	M. L. Seymour	One month's salary	$ 20 00
128	6	S. V. Peppel	One month's salary	100 00
129	Mch. 12	S. V. Peppel	Salary and traveling expenses	124 53
130	12	M. L. Seymour	One month's salary	20 00
131	12	Hann & Adair	Letter heads	12 00
132	12	C. E. Morris & Co	Iron work for cement kiln	1 65
133	29	Chas. S. Prosser	Expense account	8 00
134	Apr. 1	M. L. Seymour	One month's salary	20 00
135	1	S. V. Peppel	One month's salary	100 00
136	1	Hann & Adair	2000 stamped envelopes	44 40
137	1	E. E. Somermeir	Analyses and tests of coals	150 00
138	Mch. 31	E. E. Harrold	Chemical Laboratory supplies	20 00
139	May 17	E. E. Harrold	Chemical Laboratory supplies	41 19
140	17	M. L. Seymour	One month's salary	20 00
141	17	S. V. Peppel	One month's salary	100 00
142	June 3	S. V. Peppel	One month's salary	100 00
143	3	M. L Seymour	One month's salary	20 00
144	30	S. V. Peppel	One month's salary	100 00
145	30	M. L. Seymour	One month's salary	20 00
146	27	Samuel T. Orton	One month's salary	30 00
147	30	A V. Bleininger	One-half month's salary	50 00
148	July 8	M. W. Mumma	Traveling expenses	22 10
149	8	J. A. Bownocker	One-half month's salary and traveling expenses	104 90
150	8	Edward Orton, Jr	One month's salary	200 00
151	15	F. H. Eno	Traveling expenses	100 00
152	16	B. A. Eisenlohr	Traveling expenses	50 00
153	17	Standard Oil Co	Gasoline	5 25
154	17	P. Hayden Foundry Co	Castings for sand-brick apparatus	13 33
155	17	Columbus M. & M. Supply Co.	Supplies for sand-brick apparatus	14 63
156	17	Queen & Co	Repairing barometer	4 70
157	17	Blackwood, Green & Co	Hot closet for cement tests	2 90
158	17	H. Cole & Co	Aneroid barometer	35 90
159	19	Chas. S. Prosser	Salary and traveling expenses	106 63
160	19	Acme Paving Co.	Three sacks cement	2 50
161	19	Piqua Handle & Mfg. Co.	Two loads hard wood scrap for firing kiln	2 50
162	19	B. D. Potts	Rubber gasket	56
164	Aug. 4	Edward Orton, Jr	For salary and traveling expenses advanced B. A Eisenlohr	90 95
165	4	M. L. Seymour	One month's salary	20 00
166	4	A. V. Bleininger	One month's salary	100 00
167	4	S. V. Peppel	One month's salary and expense account	104 75
168	4	J. A. Bownocker	One month's salary	100 00
169	4	Samuel T. Orton	One month's salary	30 00
170	4	M. W. Mumma	Salary and traveling expenses	40 00
172	2	P. Hayden Foundry Co	Castings for sand-brick apparatus	12 40
173	2	Fimer & Amend	Repairing thermocouple	1 60
174	2	Harbison & Walker	300 pounds magnesite	2 90
175	2	Capital City Mch. Co.	Gas engine repairs	4 20
176	2	Acme Paving Co.	One sack cement	1 25
177	2	J. P. Carlile	Two sacks cement	1 50

DISBURSEMENTS—Continued.

Number of Warrant.	Date of Issue.	Name of Person in whose favor warrant was drawn.	Purpose of Expenditure.	Amount.
	1902			
178	Aug. 2	American Sewer Pipe Co.	One sack cement	$ 30
179	22	B. A. Eisenlohr	Expense account	77 83
180	22	Edward Orton, Jr	For cash advanced F. H. Eno for traveling expenses	150 00
181	22	M. W. Mumma	Expense account	58 55
182	22	Edward Orton, Jr	One month's salary	200 00
183	22	Edward Orton, Jr	For cash advanced in payment of small accounts	7 83
184	22	Standard Oil Co	Oil and gasoline	14 95
185	22	Columbus Citizens' Tel. Co.	Telephone service	7 95
186	22	Brandywine Summit Kaolin & Feldspar Co	One barrel crude feldspar	6 00
187	31	A. V. Bleininger	One month's salary	100 00
188	31	S. V. Peppel	One month's salary	100 00
189	31	J. A. Bownocker	One month's salary	100 00
190	31	Samuel T. Orton	One month's salary	30 00
191	31	M. W. Mumma	One month's salary	30 00
192	31	M. L. Seymour	One month's salary	20 00
193	31	C. A. Dye	One month's salary	50 00
194	31	E. G. Bailey	For labor on sand-lime brick tests	38 30
195	Oct. 4	Columbus Gas Co	Coke for firing kilns	19 66
196	Sept. 26	Samuel T. Orton	One month's salary	30 00
197	26	J. A. Bownocker	One-half month's salary and three months' expenses	212 70
198	Oct. 4	Engelke & Bigelow	Freight and cartage	42 05
199	4	Baker & Co	Repairing thermocouple	1 39
200	4	Baker & Adamson	Carbonate of potash	96
201	4	Federal Glass Co	Glass sand	1 37
202	4	Piqua Handle & Mfg. Co.	Five loads scrap wood for kiln firing	6 25
203	4	Wassall Fire Clay Co	One yard lake sand	1 50
204	4	Geo. Bobb & Son	One-half gross sample jars	2 63
205	4	Selbach Trunk & L. Co.	Case for carrying sampling tools	2 25
206	4	Andrew Spittal	Repairing gas engine	24 20
207	4	A. V. Bleininger	One-half month's salary	50 00
208	4	M. L. Seymour	One month's salary	20 00
209	6	B. A. Eisenlohr	Salary and expense account	73 61
210	13	Chas. S. Prosser	Expense account for himself and assistant and salary for himself	216 22
211	13	S. V. Peppel	One month's salary	100 00
212	16	M. W. Mumma	Salary and expense account	91 60
213	Nov. 5	S. V. Peppel	Salary and expense account	107 79
214	5	R. H. Barringer	Labor, sampling cement	6 60
215	5	M. L Seymour	One month's salary	20 00
216	13	B. D. Potts	Pipe fittings	1 06
217	18	F. H. Eno	On account salary and expense	50 00
218	Dec. 5	S. V. Peppel	Salary and expense	118 50
219	5	Columbus Citizens Tel. Co.	Telephone service	10 00
220	1	Helen Lambdin	Neostyle work	1 50
221	5	R. H. Barringer	Sampling cements	5 70
222	5	E. G. Bailey	Making sand brick tests	37 60
223	5	E. E. Somermeir	For analytical work and sampling of coals	237 10
224	5	M. L. Seymour	One month's salary	20 00

DISBURSEMENTS—Continued.

Number of Warrant.	Date of Issue.		Name of Person in whose favor warrant was drawn.	Purpose of Expenditure.	Amount.
	1902				
225	Dec.	5	Edward Orton, Jr	For cash advanced for sample Cones prepared lime	$ 1 00
226		5	Joseph Garretson	Labor, grinding cement	11 40
	1903				
227	Jan.	10	S. V. Peppel	Salary and expense account	96 10
228		14	Col. Citizens' Telephone Co.	Telephone service	10 00
229		10	Chemical Store Room	Mahler Bomb Calorimeter	211 70
230		10	G. S. Burrell	Drawing oil and gas maps	28 80
231		10	Edward Orton, Jr	Cash advanced for small acc'ts	3 95
232		10	M. L. Seymour	One month's salary	20 00
233		30	M. L. Seymour	One month's salary	20 00
234		30	Hann & Adair	1000 stamped envelopes	22 57
235		30	T. J. O'Neil	One canvas sampling sheet	1 50
236	Mch.	17	S. V. Peppel	Salary and expense account	171 51
237		20	M. L. Seymour	One month's salary	20 00
238		20	Hann & Adair	Envelopes and stationery	25 72
239		20	J. A. Bownocker	Salary and expense account	42 95
240		20	J. L Murphy	Drawing oil and gas maps	30 60
241		20	Capital City Mch. Co	Dies for sand brick	51 25
242		20	University of State of N. Y.	Packing and forwarding publications	70
243		20	C. C. Poindexter	Extra stenography	1 50
244	Apr.	16	M. L. Seymour	One month's salary	20 00
245	May	1	M. L. Seymour	One month's salary	20 00
246		1	Col. Citizens' Telephone Co	Telephone service	10 00
247		1	Carl Reynolds	Drawing oil and gas maps	164 75
248		1	E. E. Somermeir	Chemical analyses and tests of coal	210 00
249		1	Capital City Mch. Co	Repairs on dies	18 42
250		1	S. V. Peppel	Salary and expenses	112 48
251		1	W. G. Worcester	Labor on cement test	25 90
252		4	W. A. Landacre	Chemical supplies	47 98
253		2	Engelke & Bigelow	Cartage	91
254		7	S. V. Peppel	One months' salary	100 00
255	June	4	M. L. Seymour	One month's salary	20 00
256	July	31	Chas. S. Prosser	Salary and expense account	146 04
257		31	M. L. Seymour	Two month's salary	40 00
258		31	Edward Orton, Jr	One month's salary and payment of labor accounts of J. H. Chubb, C. S. Mead, E. G. Bailey, H. McMillan, and expenses 3 trips to Springfield	281 03
259		31	T. K. Lewis	Micro-photographs of cement	7 00
260		31	Columbus Citizens' Tel. Co	Telephone service	11 50
261		31	McClelland & Co	Stationery supplies	2 90
262		31	J. F. Murphy	Drawing oil and gas maps	2 10
263		31	Bucher Engraving Co	Half-tone engravings	9 97
264		31	Edward Orton, Jr	Cash advanced on small acc'ts	3 15
265		21	J. A. Bownocker	Two months' salary, 1 month's expense account	276 05
266		26	Edward Orton, Jr	One month's salary and expense account	200 45
267		26	M. L. Seymour	One month's salary	20 00
268	Oct.	4	J. A. Bownocker	One month's expense account	47 80
269		4	Engelke & Bigelow	Freight and cartage	3 94

DISBURSEMENTS—Concluded.

Number of Warrant.	Date of Issue.	Name of Person in whose favor warrant was drawn.	Purpose of Expenditure.	Amount.
	1903			
270	Oct. 5	McAllister, Mohler & Co.	Office chair	6 00
271	5	Chas. S. Prosser	Expense account of Prof. Prosser and two assistants for two months and salary for Prof. Prosser	449 52
272	5	M. L. Seymour	One month's salary	20 00
273	7	J. A. Bownocker	One-half month's salary and expenses	83 50
274	30	M. L. Seymour	One month's salary	20 00
275	Dec. 4	M. L. Seymour	One month's salary	20 00
			Total	$13,333.78

CONDENSED, CLASSIFIED LIST OF EXPENDITURES.

From April 28, 1900, to December 4, 1908.

I. OFFICE AND ADMINISTRATION EXPENSES,		
Salary and traveling expenses of State Geologist	$ 936 35	
Stenographer's salary	817 50	
Postage	150 00	
Stationery and supplies	85 42	
Library	36 25	
Furniture and office equipment	219 70	
Telephone service	49 45	
Total	$ 2,294 67	$ 2,294 67
II. REPORT ON OIL AND GAS,		
Salary and traveling expenses, J. A. Bownocker	$ 1,386 00	
Salary and traveling expenses of assistants	254 55	
Instruments, supplies, equipmen", maps, etc	42 00	
Drawing maps	236 22	
Total	$ 1,918 77	1,918 77
III. REPORT ON RAW MATERIALS FOR CEMENT MANUFACTURE,		
Salary and traveling expenses, Edward Orton, Jr	404 77	
Salary and traveling expenses, S. V. Peppel	399 47	
Freight and cartage on samples	54 34	
Preparation of samples for analysis	58 25	
Chemical analysis of samples	445 00	
Apparatus and supplies	87 98	
Total	$ 1,449 81	1,449 81
IV. REPORT ON THE TECHNOLOGY OF THE PORTLAND CEMENT INDUSTRY,		
Salary and traveling expenses, A. V. Bleininger	$ 900 00	
Salaries paid to assistants	520 75	
Apparatus and equipment	314 07	
Supplies	115 21	
Total	$ 1,850 03	1,850 03
V. REPORT ON THE UTILIZATION OF CEMENTS,		
Salary and traveling expenses, F. H. Eno	$ 300 00	300 00
VI. REPORT ON THE LIME INDUSTRY,		
Salary and traveling expenses, S. V. Peppel	$ 462 05	
Salary paid to assistants	91 50	
Freight and cartage on samples	16 28	
Preparation of samples for analysis	51 50	
Chemical analysis of samples	400 00	
Apparatus and supplies	148 58	
Total	$ 1,169 91	1,169 91
VII. REPORT ON THE LIME SAND BRICK INDUSTRY,		
Salary and traveling expenses, S. V. Peppel	$ 911 13	
Salary paid to assistants	83 85	
Supplies and equipment	113 46	
Total	$ 1,108 44	1,108 44

VIII. REPORT ON CHEMICAL COMPOSITION OF CERTAIN OHIO COALS,		
Collection of samples in the field, salaries and traveling expenses	$ 352 69	
Freight and cartage on samples	42 05	
Preparation and analysis of samples	697 10	
Apparatus and equipment	215 45	
Total	$ 1,307 29	1,307 29
IX. REPORT ON PITTSBURGH COAL IN HARRISON COUNTY, AND THE MEIGS CREEK COAL IN HARRISON, JEFFERSON AND BELMONT COUNTIES,		
Salary and traveling expenses, J. A. Bownocker	$ 232 35	
Freight on samples	3 94	
Total	$ 236 29	236 29
X. STRATIGRAPHICAL AND AREAL WORK,		
Salary and traveling expenses of Prof. Charles S. Prosser and assistants	$ 1,503 02	
Supplies and miscellaneous items	19 55	
Total	$ 1,522 57	1,522 57
XI. REPORT ON SALT INDUSTRY,		
Salary and traveling expenses, J. A. Bownocker	$ 175 00	175 00
Grand total		$ 13,332 78
Balance, subject to order		757 22
		$ 14,090 00

THE LIBRARY OF THE SURVEY.

A well equipped geological library is becoming a constantly increasing need in the doing of creditable work by the Survey. At present, the library consists of less than a hundred reports and pamphlets which have been sent in voluntarily by the surveys of other states and foreign countries. These have been accumulated during the past four years. No effort has been made to form a regular exchange list, because the Ohio Geological Survey had nothing remaining from former issues which could be offered in exchange. Now that a new series of bulletins is to be issued, it seems a proper time to take up seriously the question of exchange lists and the accumulation of a library.

The library of the Ohio State University, though not large, has been carefully selected, and now has the nucleus of a good collection of books on geology. The large geological library of the late Dr. Edward Orton has been preserved intact, and will soon be presented to the University. It would seem to be a highly desirable thing if the reports and pamphlets received by the Survey in exchange for its own publications could also be deposited in the same place. The three collections together would undoubtedly form the largest and completest geological library in the state. The books and documents contributed by the Survey could be kept separately from the others, if thought advisable, but could be indexed and used as a part of the general library. It would seem that such an arrangement would be of great advantage to the officers of the Survey, as in return for contribution of the current matter which they receive, they would have the most convenient access to all the old files of state reports and a general geological library which they could not duplicate for a large sum.

Authority to make the library of the Ohio State University the depository of all the literature obtained by the Ohio Geological Survey, by exchange or donation, will therefore be sought from the next legislature, and if granted, the plan seems likely to become of great permanent advantage to the organization and through it to the people.

BULLETIN No. 1.

THE OCCURRENCE AND EXPLOITATION OF PETROLEUM AND NATURAL GAS IN OHIO,

BY

JOHN ADAMS BOWNOCKER, D. SC.

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LIBRARY OF THE UNIVERSITY OF CALIFORNIA

CHAPTER I.

THE OIL AND GAS-PRODUCING ROCKS OF OHIO.

These have great range stratigraphically. The Trenton limestone is the lowest, and the Monongahela formation, or the Upper Productive Coal Measures, the highest. Between these extremes a large number of formations exist, which produce oil or gas in commercial quantities. These rocks differ greatly in their chemical and physical properties. This chapter enumerates the producing formations, shows their position in the geological column of the state, and gives their most important physical and chemical properties.

THE PRINCIPAL DIVISIONS OF THE GEOLOGICAL SCALE IN OHIO, AND THE OIL- AND GAS-BEARING MEMBERS.

- **Carboniferous**
  - **Coal measures**
    - Goose Run sand
    - Mitchell sand
    - First Cow Run sand
    - Macksburg 500-foot sand
    - Second Cow Run sand
    - Pottsville conglomerate
      - Salt sand
      - Maxton sand
  - **Lower Carboniferous**
    - Maxville limestone..... Mountain lime
    - Logan group.....
      - Keener sand
      - Big Injun sand
      - Squaw sand
    - Berea grit
- **Devonian**..... ..... Ohio shales
- **Silurian** .....
  - Lower Helderberg sand
  - Clinton sand
- **Ordovician**..... .....Trenton limestone

THE ORDOVICIAN.

In Ohio the upper half only of this great division needs be considered. This has been divided by Orton as follows:

	Feet.
3. Cincinnati series	300—750
2. Utica shales	0—300
1. Trenton limestone (out-crop)	0— 50

The Trenton Limestone.—Quite the reverse, however, with the first member, known as the "Trenton Limestone." Not only is this the most important source of oil in Ohio, but probably it is not excelled by any single formation in the world. It forms the floor, so to speak, of the entire state, being found wherever the drill penetrates to a sufficient depth. It outcrops only in one locality, viz., along the Ohio River, in the southwestern corner of the state; but farther south, in Kentucky, it is the surface rock over a large area, and is the basis of the famous soils of the blue grass region.

The composition of the Trenton has been made the subject of careful investigation by Orton, who found that the oil and gas bearing beds are magnesian. This is shown by the following analyses:

	$CaCO_3$	$MgCO_3$	Insol. Res.	Al_2O_3 and Fe_2O_3
Findlay gas rock.....	53.50	43.05	1.70	1.25
Bowling Green gas rock..	51.78	36.80	4.89	....
Lima oil rock.....	55.90	38.85	.75	2.94

It was further found that in some places, at least, the magnesian character of the rock changes rapidly from the surface of the formation down. Thus an analysis of the rock lying 100 feet below the top of the Trenton at Bowling Green showed over 88 per cent. of CaCO and less than 7 per cent. of $MgCO_3$; while, as shown above, the upper portion of the same formation has less than 52 per cent. of $CaCO_3$ and more than 36 per cent. of $MgCO_3$. The magnesian character is important, since it renders the rock porous, thus making it a suitable reservoir for the oil and gas. Outside of the producing territory in Ohio, the Trenton loses its magnesian character, the $CaCO_3$ composing usually at least 75 per cent. of the formation.

The rock is often highly fossiliferous, and occasionally the pieces brought up by the sand pump are little more than a cemented mass of

[1]*Geol. Survey of Ohio*, Vol. VI, pp. 103, 104.

shells, resembling in this respect the limestones of the Cincinnati series. Dr. Orton referred the formation, as shown in the Findlay well, to the Galena, Trenton proper, and Birdseye divisions.[1] The total thickness of the Trenton in northwestern Ohio is unknown, but it exceeds 780 feet. In the southwestern part of the state it is 650 feet, as shown in a well drilled on the McGhee farm in Liberty township, Adams county. This thickness is similar to that reported in Kentucky.

The relation stratigraphically of the Trenton to the next important producer, the Clinton, is shown in the following record of Well No. 1, drilled on the Haines farm, near Roseville, Sandusky County.

		Feet
Drive pipe		30
Niagara series,	Gray lime	140
	White lime	160
	Blue lime	20
	White slate, first break	2
	Brown lime, hard	21
	Light slate, second break	20
Clinton limestone		100
Medina shales (red)		80
Cincinnati series (white shales)		427
Utica shale (brown)		252½
Trenton limestone at		1,252½

For comparison, a record is given of a well drilled on the Rohr farm, near Groveport, Franklin county, in the central part of the state:

	Feet
Drift	136
Ohio shales	167
Corniferous limestone, top at	303
Niagara limestone, bottom at	980
Clinton shales	110
Clinton sand, shells only at	1,110
Trenton limestone at	2,146
Bottom of well (in Trenton)	2,675

THE SILURIAN.

The rocks of this age in Ohio are divided by Orton as follows:[2]

		Feet
4.	Lower Helderberg limestone	50—600
3.	Niagara limestone and shale	125—380
2.	Clinton group	20—150
1.	Medina shale	25—150

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 116. [2] *Ibid*, Vol. VII, pp. 4, 5

The Clinton.—Of these divisions, the second and fourth only call for recognition in this chapter. Along its line of outcrop in southwestern Ohio, the Clinton consists essentially of a highly crystalline limestone, rich in fossils, especially crinoid stems. Commonly it has a light color, the tint of which varies from place to place. The rock takes a good polish, and is sometimes called marble. Occasionally the formation contains lean hematite, and one of the earliest blast furnaces in the state relied on this ore. In composition the rock is calcareous, and at one point becomes the purest rock of this type in the state.

Northward, under cover, the rock undergoes notable changes, the result being that it closely resembles the overlying Niagara. It is in the central portion of the state, however, that the greatest change is found. Instead of a well-marked limestone, there is found in its place shales of different colors and composition and a conspicuous sandstone; the latter the repository for the great reservoirs of gas in Fairfield, Hocking, Licking and Knox counties. In northern Vinton county a pool of oil also has lately been found, and one well has been secured in Perry county.

The relations of these beds to the overlying Niagara are shown in the following partial log of a well on the Bauer farm, near Sugar Grove. Samples of drillings below the Niagara were taken by the writer:

			Feet
Berea grit		top at	620
		bottom at	645
Corniferous, Helderberg, and Niagara limestones		top at	1,430
		bottom at	2,132
Clinton	Shales, light chocolate-colored. Little lime	top at	2,132
		bottom at	2,168
	Shales, green and chocolate-colored, the latter fossiliferous. Some lime.	top at	2,168
		bottom at	2,199
	Shales, green and chocolate-colored. Much lime	top at	2,199
		bottom at	2,236
	Clinton sand at		2,236

Generally when the gas sand has been penetrated to a depth of from 10 to 15 feet the drill is stopped, and consequently data farther down are less abundant. In western Ohio the basal portion of the Niagara is commonly occupied by shales,[1] but northward and eastward this member contracts. In central Ohio it consists of shales and thin beds of limestone, and the bottom of these is regarded as the line of junction of the Niagara and the Clinton.

[1] *Geol. Survey of Ohio*, Vol. VII, pp. 11-13.

The following skeleton record of a well on the Spire farm, near Sugar Grove, shows the position of the Medina as well as the Clinton:

		Feet
Drift		11
Berea grit, bottom at		460
Corniferous, Helderberg, and Niagara limestones	top at	1,235
	bottom at	1,921
Clinton sand	top at	2,025
	bottom at	2,045
Medina (red shales) top at		2,055
Bottom of well at		2,075

This makes the red shales, lying from 10 to 30 feet below the Clinton sand, the top of the Medina.

The Lower Helderberg.—Rocks of this age produce gas and oil in one locality, viz., near Jefferson, Ashtabula county. The succession of strata there is shown by the following record of Webb Well No. 1. All measurements were made with a steel line.

	Thickness of formation. Feet.	Total depth. Feet.
Drift	33	33
Ohio shales	1,671	1,704
Corniferous and Lower Helderberg limestones	288	1,992
Gas sand at		1,992

The sand, which is from 30 to 40 feet in thickness, is interbedded in the Lower Helderberg limestone. Similar conditions are found in Lucas and Wood counties, in the former of which the sand has been quarried for the manufacture of glass.[1] In the gas field under consideration the sand is moderately coarse, has a light color, and is highly fossiliferous. The gas is found in the top of the formation, and just below lies a large and threatening reservoir of salt-water. A number of towns and villages are being supplied with fuel from this field. The oil wells are few in number and insignificant in production.

THE DEVONIAN.

The rocks of this age, found in Ohio, have been classified by Orton[2] as follows:

	Feet.
3. Ohio shales	250—3,000
2. Olentangy shale	25
1. Devonian limestone (Corniferous)	75

[1] *Geol. Survey of Ohio*, Vol. VII, p. 17.
[2] *Ibid.*, pp. 4 and 18-26.

None of these formations produce oil, and the Ohio shales alone yield gas. The available supply of this, however, is very small, and its use has been limited to domestic purposes. The principal counties have been those along the lake shore, in the northeastern corner of the state. These shales, which underlie the eastern half of the state, are wedge-shaped, with the apex reaching from the lake to the Ohio. The cities, Columbus, Delaware and Bucyrus, lie on or near this apex. Eastward the formation thickens rapidly, and near Wellsville, on the Ohio River, has been penetrated to a depth of 2,600 feet without reaching the base. This feature has led to much confusion on the part of the driller, who has expected to find the interval between the Berea grit and the Devonian limestone, the same in the eastern part of the state that he did in the central.

The gas secured in these shales is not from any one horizon, but varies stratigraphically from place to place. The wells are all small. Very commonly the shales make a show of gas, but usually the yield is so light as to be commercially valueless. The aggregate amount contained, however, must be very large, and if it could be collected would form one of the most valuable supplies of fuel in the state.[1]

THE CARBONIFEROUS.

Classifying the formations of this great division, as has been customary, into the Lower Carboniferous, Coal-measures, and Permian, it is found that the oil and gas bearing rocks are restricted to the first two members. These will now be considered in order.

I. THE LOWER CARBONIFEROUS.

The Berea Grit.—This is the most extensive sandstone of the state. Its area above and below drainage is about 15,000 square miles, or more than one-third of the area of the state. Its value is commensurate with its extent. "Its economic value above ground is great, but it is greater below. In its outcrop it is a source of the finest building-stone and the best grindstone grit of the country, and when it dips beneath the surface it becomes the repository of invaluable supplies of petroleum, gas and salt water."[2]

The composition and structure are very constant. The color is gray below drainage, but has a tinge of yellow above. The sand is of moderate fineness, and composed almost wholly of silica. Occasionally it contains carbonate of lime, probably as a cement, but this never constitutes more than a very small fraction of the formation. That found

[1]For a full discussion of this subject see *Geological Survey of Ohio*, Vol. VI, pp. 410-442.

[2]*Ibid.*, Vol. VII, p. 28.

below the surface, around the village Berea, in Cuyahoga county, is undistinguishable from that obtained at a depth of more than 2,000 feet in Washington county. Sometimes, though not usually, the formation divides, a bed of shale lying between two of sandstone; at other places the upper portion of the formation consists of sandstone and the lower of shales. In thickness the formation varies from 50 feet or more in the northern part of the state to a half dozen or less in the southeastern portion, and occasionally disappears entirely, its place being occupied by shales. The Berea grit is succeeded above by the Berea (Sunbury) and Cuyahoga shales, having usually an aggregate thickness of from 500 to 600 feet, and below by the Ohio shales, having a great and rapidly increasing thickness eastward. The most remarkable character of the formation, however, remains to be mentioned, viz., its persistence. From its outcrop it has been followed by the drill from county to county, and often from section to section, until the eastern and southeastern limit of the state is reached. It is as easily recognized below drainage as above, and this character makes it a stratigraphical landmark of great value to both driller and geologist. In many counties in the eastern part of the state, especially those fronting on the river, numerous efforts have been made to find a productive sand below the Berea, but in every case this effort has been unsuccessful. It may now be taken as having been demonstrated by the drill that when the Berea sand has been passed in this territory the last hope of oil or gas has gone.

While a trace of oil or gas has perhaps been found in every county where the formation exists, the production in commercial quantities is limited to Lorain, Medina, Trumbull, Columbiana, Stark, Jefferson Harrison, Belmont, Guernsey, Monroe, Noble, Vinton, Perry, Athens, Morgan and Washington counties.

The Logan Group.—The relative position of this group and the Berea is shown by the following skeleton record of a well on the Mead farm, in the Elk Run Pool, Washington county.

			Feet.
Pottsville conglomerate	Salt sand	top at	1,200
		bottom at	1,280
	Maxton sand.....	top at	1,450
		bottom at	1,500
Maxville limestone	Mountain limestone ("Big lime")	top at	1,510
		bottom at	1,545
Logan group	Big Injun series....	top at	1,560
		bottom at	1,730
Berea grit		top at	2,124
		bottom at	2,138

This shows that the two formations are about 400 feet apart, and as has already been stated, the interval is occupied by the Berea and Cuyahoga shales.

The Logan group, as classified by Orton, consists of three members—a conglomerate, sandstone and shale—and has a maximum thickness of 350 feet.[1] Quite recently, however, Professor Prosser has considered the question, and he divides the group as follows:[2]

2. Logan formation = Logan sandstone and shales.
1. Black Hand Formation = Logan conglomerate.

The Big Injun series is limited above by the Lower Carboniferous or Maxville limestone, which in Monroe, the southeastern corner of Belmont and the eastern part of Washington counties is known as the Mountain limestone, or, popularly with the driller, as the "Big lime." Outside of the two counties just named, however, this limestone is not reported, and hence the upper limit of the Big Injun is not so well marked. In fact, over a large part of eastern Ohio, this formation and the Salt sand are confused by the driller, who applies the latter name to the Big Injun.

Above drainage the group is well marked. Hills capped with sandstone or conglomerate stand out in bold relief, so that the limits of the formation are discernible from a distance. The conglomerate is the most conspicuous member of the group. It is essentially a quartz rock, the largest pebbles of which do not commonly exceed one-half of an inch in diameter. It is the best known bridge stone in the state. The sandstone member has usually a yellow or brown color, but sometimes this becomes strikingly variegated. It is extensively used for building purposes. The members of this group are much less constant in their physical characters than the Berea grit, and hence their identification is correspondingly more difficult.

Under cover the Logan group undergoes important changes, and the several formations are given different names from those at the surface. Thus, instead of the Logan conglomerate, sandstone and shale, we have the Keener, Big Injun and Squaw sands.

The Mountain limestone has been shown by paleontological evidence to be the equivalent of the Maxville or Subcarboniferous limestone. The formation is known in West Virginia as the Greenbrier limestone. In Ohio it has a maximum thickness of 110 feet. It is a light-colored, hard, massive rock, free from oil and gas except along its margin, where the formation becomes broken and the layers of limestone are intercalated with sandstone. The formation is wedge-shaped, with the apex to the northwest. It is limited to the eastern half of Washington and Monroe

[1] *Geol. Survey of Ohio*, Vol. VII, p. 32.
[2] *Journal of Geology*, Vol. IX, p. 215.

counties, and the southeastern corner of Belmont. To the west and north its place is occupied in part at least by shales and sandstones. The formation makes the summit of the Lower Carboniferous, and serves as a guide-post to the driller.

The Big Injun Series.—This consists of the following members:

Slate	0— 20 feet
Keener sand	0— 60
Slate	0— 25
Big Injun sand	0—175
Slate	0— 10
Squaw sand	0— 30

From this it is seen that the group varies greatly. Sometimes it is little more than one great mass of sandstone, while at other times it is broken into a series of alternating beds of slate and sandstone. The Keener sand occasionally lies immediately below the Mountain limestone, but more often is separated from that rock by a few feet of shales. It varies considerably in texture, but is usually coarse and open, sometimes conglomeritic. The sand was named from the Keener farm, near Sistersville, West Virginia.[1] It is an important source of oil in Monroe and Washington counties. The sand is separated from the underlying Big Injun by a bed of slate. Sometimes the latter is wanting, and then the two sands run together and are conjointly called the Big Injun. The sand in question (Big Injun) is by far the thickest member of the series, but in other respects resembles the Keener. It is recognized in several counties in southeastern Ohio, but is a producer of oil or gas in commercial quantities in Monroe and Washington counties only. To the west and north the formation becomes too broken to be a repository for oil or gas. Below the Big Injun, and separated from it by a thin bed of shales, there is occasionally found another layer of sand known as the Squaw. It is decidedly patchy, and never extends over large areas in this state. The best records of it are reported from Monroe county, but it is of little importance even there.

II. THE COAL MEASURES.

These include not only the formations containing seams of coal, but also several hundred feet of rock lying between the Sharon or No. 1 coal and the Mountain limestone. This is part of the great Pottsville conglomerate. For convenience the rocks of the Coal-measures will be divided into first, the Pottsville Group; second, the Coal Measures proper.

Pottsville Group.—This group of sands lies in the lower part of the Pottsville conglomerate, that is, between the Sharon or No. 1 coal and

[1] *West Virginia Geol. Survey*, Vol. I, p. 357.

the Mountain limestone. It may be well to state that in Southeastern Ohio the Pottsville formation loses its conglomeritic nature, and becomes sandy and shaly. There are two sands that should be noticed, viz., the Salt sand and the Maxton sand.

The relative positions of these are shown in the Mead farm record given on page 23.

The Maxton Sand.—This rests immediately on the mountain limestone, or is separated from it by a few feet of shales. The sand has been reported in the eastern part of Washington and the southern part of Monroe counties only. Its area is small and within this the sand is patchy. It is of little importance as a producer of oil or gas.

The Salt Sand.—This sand, as its name indicates, contains much salt water. It was the source of the brine of the salt works which formed so important an industry in southeastern Ohio one-half century ago. Testing for it was an important aid in proving the existence of oil in the rocks of the Coal-measures. It is very generally confused with the Big Injun sand in those counties where the Mountain limestone is not found. The Salt sand is not important as a producer of either oil or gas.

Coal-Measures Proper.—While a large number of strata belonging to the Coal-measures have been or are now sources of oil, comparatively few of these have been important in a commercial sense. Generally the sands are local, and cannot be traced over an area of more than a fraction of a mile. Such sands usually have names, but because of their small area and production they will not be further noticed in this article. The most important sands of the Coal-measures are the following:

5. **Goose Run sand.**
4. **Mitchell sand.**
3. **First Cow Run sand.**
2. **Macksburg 500-foot sand.**
1. **Second Cow Run sand.**

The relative positions of sands 1 and 3 are shown by the following data taken from Centennial Well No. 6 at Cow Run:

	Thickness. Feet.	Depth to top of formation in feet.
Pittsburg coal	1	11
First Cow Run sand	47	325
Second Cow Run sand	64	776

The stratigraphical relation of sands 2 and 3 is shown by the following record taken from Dunn Well No. 6, near Macksburg. The well head is six feet below the Meigs Creek coal.

	Thickness. Feet.	Depth to top of formation in feet.
Ames limestone	1	285
First Cow Run sand	5	385
Cambridge limestone	4	411
Dunkard sand (300-foot)	95	530
Macksburg 500-foot sand	22	702

The Dunkard or 300-foot sand is quite generally regarded as the equivalent of the Mahoning. That this cannot be correct is shown by the following partial section of the Hocking Valley coal field.[1]

	Thickness in feet.
Cambridge limestone	2-10
Mahoning sandstone, upper division	50
Brush Creek coal (No. 7*a*)	2½
Brush Creek limestone	4
Mahoning sandstone, lower division	15-25
Upper Freeport coal	0- 3
Upper Freeport: Clay, Shales, Limestone and sandstone	35
Middle Kittaning coal (No. 6)	5-13

This shows the Mahoning sandstone lying immediately below the Cambridge lime, but experience in the field demonstrates that the two are not ordinarily in contact. Measuring from the base of the lime rock to that of the Mahoning, an interval of 76 feet is found, while, according to the records in the Dunn well, the interval is 210 feet. A divergence of this sort cannot be explained by assuming that the section expands eastward, for a study of the relative positions of the Pittsburg coal, the Ames and Cambridge limestones farther west with the same formations near Macksburg, shows no material change, and it is certainly unreasonable to assume that the formations just below the Cambridge limestone expand at anything like the rate that would be necessary to make the interval which this nomenclature requires. Further, naming the sand in question the Mahoning makes impossible a rational classification of the lower formations. The position of the sand with reference to the Cambridge lime is that of the Upper Freeport.

The positions of sands 3 and 4 are shown by the record of Centennial Well No. 7, at Cow Run. The well head is at the horizon of the Meigs Creek coal.

	Thickness. Feet.	Depth to top of formation in feet.
Pittsburg coal (No. 8)	1	116
Mitchell sand	25	205
Red shales ("Big Red")	80	235
First Cow Run sand	32	423

[1] *Geol. Sur. of Ohio*, Vol. V, p. 918.

The relative positions of sands 4 and 5 are shown by the following taken from Reed Well No. 4, near Marietta:

Goose Run sand	top at	300
	bottom at	331
Mitchell sand	top at	525
	bottom at	546

The Second Cow Run Sand.—This is one of the least important members of the group now under consideration. It has been a small producer at Cow Run in Washington county for more than thirty years, but rarely has been found beyond that locality. It is reported, however, quite frequently, for the driller gives this name to almost any sand lying from 100 to 500 feet below the first Cow Run sand. As may be seen from the records given the interval between the two is 400 feet. It lies 760 feet below the Pittsburg coal, and is the thickest member of the group, sometimes exceeding 60 feet. Occasionally the formation is divided by a few feet of slate, in which case the oil lies in the lower part. The sand possesses no qualities that serve to distinguish it from the higher members.

The sand belongs near the base of the Coal-measures. The partial record of the Rice well, given below, shows it to be the first sand above the Salt sand, the two being separated by 79 feet of shales, the latter probably the equivalent of the shales of the Logan group. This, with the thickness of the formation, and the fact that it is sometimes divided by a few feet of shales, makes quite certain its identification as the Massillon sandstone.

The Macksburg 500-Foot Sand.—This is important at Macksburg and vicinity only. It lies 670 feet below the Meigs Creek coal and about 580 feet below the Pittsburg, as is shown in the following partial log of George Rice Well No. 18, at Macksburg:[1]

	Thickness. Feet.	Depth to top of formation in feet.
Meigs Creek coal	5	10
First Cow Run sand	35	343
Dunkard sand (300-foot)	78	554
500-foot sand	17	685
Sand, pebbly (800-foot)	51	775
Slate	79	826
Salt sand	190	905

This sand commonly ranges from 10 to 30 feet in thickness. It is usually quite coarse, but does not become a conglomerate. Like the First Cow Run sand, it does not form a continuous stratum, but is decidedly patchy. Stratigraphically considered, the formation belongs near the top

[1] *West Virginia Geol. Sur.* Vol. I, p. 298.

of the Conglomerate Coal-measures, and its position with reference to the Cambridge lime and Dunkard sand strongly indicates that it is the Tionesta sandstone.

The Second Cow Run and the Macksburg 500-foot sand have been regarded by many as equivalent. As has already been suggested by Professor White, however, this cannot be the case.[1] Examination of the record of the Rice well shows that the interval between the First Cow Run and 500-foot sands is only 307 feet, while, as already stated, the interval should be 400 feet. Measuring from the Meigs Creek coal, equally conclusive figures are secured. Thus the Second Cow Run sand lies 840 feet below the Meigs Creek coal, while the interval between this seam and the 500-foot sand is only 670 feet. The sand at Macksburg known as the 800-foot is probably the equivalent of the Second Cow Run.

The First Cow Run Sand.—This is the most important and best-known sand of the group. As is shown in the record of the Dunn well, its position is 100 feet below the Ames limestone. In western Morgan county, near the outcrop of the sand, the interval ranges from 70 feet to 100. The Ames limestone there lies 170 feet below the Pittsburg coal. The identification of the sand is made more certain by the fact that the Cambridge limestone lies immediately below or is separated from the sand by a thin bed of shales. Unfortunately these limestones are not recognized in Monroe and the eastern part of Washington counties, hence the sand in question often cannot be identified there with certainty. In such localities any shallow sand, especially if it makes a show of oil or gas, is known as the Cow Run. The relation of the sand to the two limestones places it about 100 feet above the base of the Conemaugh formation.

If the Berea grit be taken as the type of a persistent stratum of sandstone, the First Cow Run sand may properly be selected as the representative of the opposite type. It is the most patchy of the oil or gas rocks of Ohio. The maximum thickness of the formation may be taken at 50 feet, but even a short distance from this the stratum may become very thin or actually disappear entirely. The texture varies much, and where productive is sometimes conglomeritic. Pebbles three-fourths of an inch in diameter have been found, and those one-fourth of an inch are common. The pebbles consist of quartz, but small grains of other minerals are found. From this type the formation changes to a hard compact sandstone.

The sand is an important source of oil in Morgan and Washington counties. It seems to have been first struck at Macksburg in 1860, where it is known as the 140-foot sand; this being the depth at which the sand was found in the valley at that place. In 1861 the sand was found at Cow Run and has there been a producer ever since. It is seen that the latter name has not the claim of priority, but it is so much more widely used that it is here retained.

[1] *West Virginia Geol. Sur.* Vol. I, p. 299.

The Mitchell Sand.—This is the source of a small oil field a few miles east of Marietta. The sand is comparable in thickness with the First Cow Run, but in texture is less conglomeritic. As has been shown, it lies about 90 feet below the Pittsburg coal, or 200 feet above the First Cow Run sand. Its place is near the summit of the Conemaugh formation. Wells in this sand commonly begin with a relatively large production, but decrease very rapidly.

The Goose Run Sand.—The formation known by this name has supplied a score or more small wells near Marietta. The sand is patchy, and the life of the wells very short. In fact, the rock is of little value, and is recognized here simply to make the record complete stratigraphically. Lying nearly 200 feet above the Mitchell, the sand belongs 100 feet above the Pittsburg coal, or, in other words, near the middle of the Monogahela formation.

The following table shows the great divisions of the Coal-measures proper in Ohio, and also the approximate positions, at least, in these of the several sands just discussed:

Dunkard Formation, or Upper Barren Coal-measures, 500 feet.	No oil or gas rocks.
Monongahela Formation, or Upper Productive Coal-measures, 200 feet.	Goose Run sand. 100 feet (interval). Pittsburg or No. 8 coal.
Conemaugh formation, or Lower Barren Coal-measures, 500 feet.	90 feet (interval). Mitchell sand. 200 feet (interval). First Cow Run sand. Cambridge limestone. Mahoning sandstone.
Allegheny Formation, or Lower Productive Coal-measures, 250 feet.	Upper Freeport or No. 7 coal. Dunkard or 300-foot sand=? Freeport sandstone. 50 feet (interval).
Conglomerate Coal-measures, 250 feet.	Macksburg 500-foot sand=? Tionesta sandstone. 70 feet (interval). Second Cow Run sand=? Massillon sandstone. Sharon or No. 1 coal.

CHAPTER II.

THE TRENTON LIMESTONE AS A SOURCE OF OIL AND GAS.

This article is largely a review. The exhaustive reports of the late Dr. Edward Orton, published in 1888 and 1890, have greatly limited the field of the present writer. The early historical data contained in this chapter are based almost wholly on the reports of the geologist just named, and the same is true of the fundamental principles of the geology of the field. The present writer has merely taken up the work where Dr. Orton laid it down, attempting to show the progress made and the present state of the industry.

THE DISCOVERY OF OIL AND GAS IN THE TRENTON.

Knowledge of the existence of oil and gas in the rocks of Ohio dates back almost to the period of the state's admission into the union. This resulted quite largely from the search of the pioneers for that necessary article, common salt. Thus a well drilled in 1814, near the village South Olive, Noble county, with this in view found such a pressure of gas that it threw the water and some oil to a height of from 30-40 feet, and these eruptions were continued as late at least as 1838.[1] About the same time both oil and gas were discovered in Washington county to the south. The petroleum was called Seneka oil, and was used in a small way for medicinal, illuminating, and lubricating purposes. Similar results were secured at many points in the southeastern part of the state, but the oil and gas were regarded as a nuisance. The former ruined the brine for the manufacture of salt, and the gas was regarded too dangerous. Deep wells, however, did not furnish the only evidence of mineral wealth stored in the rocks below. Sometimes ordinary water wells would liberate small quantities of oil or gas, and occasionally these products were found in still shallower excavations. At a few points oil was found as a very thin film on the surface of streams, and occasionally gas escaped with spring waters, the combination having been known as gaseous springs. It is interesting to note that evidence of this kind led later to tests at several points with the result that valuable pools of oil and reservoirs of gas were discovered in Washingon, Morgan and Knox counties, and finally the great Trenton limestone field itself.

[1] *Geol. Sur. of Ohio*, First Ann. Rept. 1838, p. 62.

The Discovery at Findlay.—These early discoveries of gas played a small part in the fuel supply of the state; in fact they were little more than scientific curiosities. The same is practically true of oil; for while the total value of the production from 1860 to the close of the year 1884 was $579,223,[1] it is significant in comparison with the vast treasure that has been taken from our rocks since that time. Had the state's production of oil and gas terminated with the year 1884, these products would never have been ranked among the important sources of wealth in Ohio, nor would the state have been mentioned, except in a passing way, in works devoted to these fuels. The importance of the discovery at Findlay was estimated by Dr. Orton in 1888 as follows:— "No geological discovery ever made in the country, unless the original discovery of petroleum in western Pennsylvania shall be excepted, has exerted so widespread and powerful an influence on half of the United States, or at least on the northern Mississippi valley, as the discovery of Findlay gas."[2] Viewed from the the standpoint of the production of wealth, however, the discovery of gas was of small importance in comparison with that of oil; for the Trenton limestone must now be rated as one of the first, if not the first, formations in the world as a source of petroleum.

Indications of natural gas had long been noted at Findlay and vicinity; along the banks of the Blanchard river the gas found its way to the surface, and it was also found in small quantities in digging water wells and sewers.[3] The earliest specific mention of the fuel was made in 1836 when it was struck at a depth of perhaps ten feet. The gas was ignited, and the flame is reported to have been maintained for a period of three months. In 1838 a stronger flow was found, this time in the town of Findlay; and the fuel, collected in rude fashion, was used in a residence. It is interesting to report that gas was still being used in this manner in the residence referred to when the great discovery was made in 1884. As early as 1864 Dr. Charles Oesterlin, a citizen of Findlay, urged the construction of reservoirs to store the natural gas, preparatory to using it for domestic purposes.[4] However, his ideas were in advance of his time and nothing came from them. Twenty years later the neighboring state, Pennsylvania, was enjoying benefits resulting from the discovery of vast volumes of natural gas. The people of Ohio were quick to see the possibilities of the new fuel and began testing the underlying rocks for it. This work aroused Dr. Oesterlin's interest which had been dormant for twenty years, and in the spring of 1884 he succeeded in organizing a company to test the rocks at Findlay.[5] An experienced driller was secured from Bradford, Pennsylvania, and on October 20 work was begun. Small volumes of gas were found at several horizons, the supply being adequate for drilling. At 1092

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[1] *Mineral Resources of the U. S.*, 1900, p. 542.
[2] *Geol. Sur. of Ohio*, Vol. VI, p. 117.
[3] *Ibid*, p. 109. [4] *Ibid*, p. 110. [5] *Ibid*, p. 111.

feet a much larger flow was found, sufficient to produce a flame from 20 to 30 feet in height. This attracted much attention in northwestern Ohio and produced great excitement at Findlay. With the hope of finding a larger body of gas the drill was kept at work until the rock in which the fuel was found had been penetrated to a depth of 556 feet, but without success. While this well was small it demonstrated the presence of gas in the underlying rocks, and this was sufficient to make further exploration certain. The Findlay Gas-Light Company quickly saw the significance of the new discovery, and began drilling a well in December, 1884. The results were very similar to those secured from the first well, but the company turned the gas into its lines and Findlay for the first time was using natural gas.

Well No. 3, completed in June, 1885, was likewise small, but No. 4 had an initial flow of 1,250,000 cubic feet in 24 hours,[1] and was the first that could be rated successful. More, however, remains to be said of this well; oil appeared "at the same time and at the same horizon, at which the gas was found."[2] Later the quantity of oil increased, becoming about five barrels per day late in 1885. When the Karg well was completed the gas in the well under consideration decreased, but at the same time the oil increased from 5 to 15-20 barrels per day. Facts pertaining to this well have been given with some detail since it seems to have been the first in the vicinity of Findlay from which oil was secured in the Trenton limestone. Well No. 5 also showed some oil; but this was regarded as a nuisance, and an effort was made to exclude it from the gas rock by inserting a plug, the oil apparently coming from a lower horizon than the gas. The effort was only partially successful. Well No. 7, drilled in November, 1885, had an initial production of 3,335,000 cubic feet per day, making it the largest up to that time in the field. The next well was a failure as a producer of gas, but after having been shot with 100 quarts of nitro-glycerine it began flowing oil at the rate of 300 barrels per day. The volume decreased rapidly, but the well was by far the largest producer of oil yet drilled in the new field.[3] Wells from Nos. 9 to 12 inclusive displayed no new features, or striking characteristics, and hence will not be further mentioned in this report.

It remained for the next well, "unlucky thirteen," to revolutionize the history of the field, and to make Findlay for a time the most conspicuous town in Ohio. This was the Karg well. It was located near the railroad station in Findlay, and was drilled by the Findlay Gas-Light Company. Work was begun in December, 1885, and the well was completed 24 days later. The Trenton limestone was struck at 1,118 feet, but the flow of gas was small and the drill was kept at work, as was customary under such conditions, with the hope of finding a larger supply. At 1132 and 1138 the flow increased, and at 1144 it became so great that the tools

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 122.
[2] *Ibid*, p. 123. [3] *Ibid*, p. 126.

were powerless to advance. The escaping gas seemed to make the earth tremble, and the roar could be heard several miles. When lighted the flame could be seen 40 miles away. The flow of gas was measured by Professor Robinson and found to be 12,000,000 cubic feet in 24 hours. It was the largest well that had been drilled up to that time in Ohio, and gave new character to the Findlay field.[1] The discovery of oil and gas in the Trenton limestone has now been reviewed. It will be in order to consider each separately from this time, and since gas was first discovered, and also first to make its presence felt, it will be given the place of priority in this volume.

A RESUME OF THE HISTORY OF NATURAL GAS IN NORTHWESTERN OHIO.

Drilling in Findlay continued and by the spring of 1888 the eighteenth well had been completed. None of the later ones, however, were large, the best not exceeding 2,500,000 cubic feet per day. From Findlay as a center drilling radiated in all directions, and it was not long until the limits of the gas producing belt had been determined. This extended north and south a distance of 25 miles and in a general way was limited by Findlay on the south and Bowling Green on the north. The richest territory included seven townships in Hancock county and six in Wood. It follows from what has been said that the producing territory did not form a line or ridge, but a broad belt in some places 15 miles or more in width. The wells secured outside of the corporation of Findlay were similar to those secured within; some were small, others large, a few gigantic. The Tippecanoe well was a good illustration of the latter type; it was located two miles north of the court house, and when the Trenton rock had been penetrated to a depth of 70 feet a good flow of gas was found. With the hope of increasing this the well was torpedoed, the result being the strongest flow of gas that had yet been secured in Ohio. Measurements made on the first three days of the well's existence showed productions of 32,000,000, 24,000,000 and 19,000,000 cubic feet respectively.[2] It is interesting to report that the owners of this well offered to sell it to the Findlay municipal natural gas plant, but the trustees of this declined to purchase, and began drilling a well only 60 feet from the Tippecanoe. The result was a total failure, and shows the extreme capriciousness of the industry, even when in territory that is regarded most promising. The Van Buren was another famous well. It was located on section 12 of Allen township, and was completed in October, 1886, but was not tubed for a month later, when it flowed nearly 13,000,000 cubic feet through a four-inch pipe in 24 hours. Two additional giants were drilled in this township; one known as the Hutson, on section 17, had an initial production

[1] *Geol. Sur. of Ohio*, Vol. VI, pp. 129-130.
[2] *Ibid*, First Ann. Rept., 1890, p. 117.

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at the rate of 32,000,000 cubic feet per day; and the other, named the Mellott, on section 30, yielded at the rate of 27,000,000 cubic feet in the same time.[1]

The territory in Wood county joined that in Hancock, thus forming one field. The general character of the wells in Wood county was similar to that in Hancock county, but no such giants were reported. Bloom township contained the best territory, more than 40 wells having been drilled in it. The largest of these, the Simons, had an initial production of 12,000,000 cubic feet per day.[2]

As soon as gas was discovered at Findlay the owners of the well began preparations to supply the town. A few weeks later the Gas-Light & Coke Company completed a well, the second one drilled in the field, and turned the fuel into its lines. This precipitated a fight between the two organizations, the first effect of which was the laying a second set of pipes through the city, and later the absorption of the first-named company by the second one. The rates established were reasonable enough, but to the citizens it appeared that they had fallen into the clutches of a monopoly, and a demand was made that the city should own and operate its own wells. Accordingly the legislature passed an act granting the citizens a right to vote on a proposition to bond the municipality for $60,000, the money to be used in drilling wells, laying pipes, etc. It is scarcely necessary to state that the proposition carried by a large majority. A third set of pipes were laid through the town and drilling of wells begun. The first one was completed in November, 1886; others followed in quick succession, so that the municipality soon had an adequate supply of gas.[3] The gas trustees met the popular demand by cutting the existing rates in two, but the Gas-Light & Coke Company, not to be outdone, responded by dividing in a similar manner the rates of the municipal plant. The trustees of the latter at once met the rates of the old one, but the latter organization preferred that the "merry war" go on, and each company made one further reduction. By that time the cost of a fire per month had been reduced from one dollar to fifteen cents. The Gas-Light & Coke Company was preparing to reduce its rate from fifteen cents to five, when it was purchased by the trustees of the municipal plant and thus the contest was brought to a close. This done prices again advanced; on November 1, 1888, they became 50 cents for each stove if paid before the tenth of the month; on October 1, 1889, rates were practically doubled, and later they were still further increased. At present (1902) the rates are 30 cents per thousand cubic feet, with a discount of 5 cents if the bills are paid before the tenth of the month.

Almost as soon as gas was discovered it began to be used in such factories as then existed in Findlay. As the wells increased in number

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[1] *Geol. Sur. of Ohio*, First Ann. Rept., 1890, p. 125-6.
[2] *Ibid*, p. 135. [3] *Ibid*, Vol. VI, p. 140-1.

and strength, outside plants were attracted to the place, and new corporations were established. The great attraction, of course, was free fuel, guaranteed in some cases for five years. This was sometimes supplemented by gifts of land on which to locate factories, and sometimes still further inducements were made. The result was a steady growth of the town during two years and then a shorter period of wild speculation. The city limits, which at the time of the discovery comprised four square miles, were extended until they included an entire township. Land sold at exorbitant prices, and the population of Findlay increased from 4,500 in 1884 to 25,000 in 1889. The fall of that year saw the crest of the speculative wave pass and then the reaction began.[1]

The uses made of the new fuel were many. They included glass houses, iron industries of various kinds, lime kilns, and brick yards. Those interested did their best to convince the people that the supply was unlimited, or that it was being produced in the interior of the earth as fast as taken out. With such seductive theories, and the fact that gas was furnished free or nearly so, it is no wonder that vast quantities were wasted. The city itself led the extravagance, illuminating its streets by torches burning by day as well as by night, and wasting in this manner alone at least 15,000,000 cubic feet per month during part of the year 1887. The great wells themselves were frequently ignited to interest people who had visited the city through curiosity, or to impress those with capital to invest. Factories used the fuel in a reckless manner, and private residences were not behind in this respect. To many it seemed easier to raise a window or open a door than to turn down the gas.

The result is well known. The time came quickly and suddenly when the citizens of Findlay were brought face to face with an inadequate supply of gas. This first became manifest early in the winter of 1888, when many of the plants were compelled to shut down during a part of the day owing to a shortage in the fuel supply. During the coldest weather one of the public schools was dismissed and at such times many complaints were received from residences. One of the troubles was the presence of salt-water in the pipes, the effect of which was to shut off the gas. The water was soon traced to the Karg well, and those who had given any consideration to the subject saw at once that the great well was doomed. It became evident that if Findlay's supply of gas was to be maintained new territory must be secured, and early in 1889 the corporation leased nearly 8,000 acres in the northern part of the county at an annual rental exceeding $50,000. Later in that year good wells were secured on this territory so that Findlay again had an ample supply.[2]

Such in brief was the early history of natural gas at Findlay. The following letter gives the financial history of the municipal plant. It will

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 141-150.
[2] *Ibid*, First Ann. Rept. 1890, p. 113-6.

be seen from this that the plant was successful, even though at times the fuel was wasted or sold at absurdly low figures. The letter is from the Prosecuting Attorney of the county:

FINDLAY, OHIO, January 16, 1903.

MY DEAR SIR:

In reply to your leter of recent date, asking for information regarding Findlay's gas plant, I herewith submit the following, the amounts and dates having been given me by Mr. Ray, the City Clerk:

The first bonds issued for the construction and maintenance of the gas plant at Findlay amounted to forty thousand dollars and were sold September 1, 1886. Other issues followed as money was needed for the construction of the plant, being ten thousand dollars October 5, 1887; eight thousand dollars issued February 11, 1888; forty thousand dollars September 4, 1888; twenty thousand dollars September 24, 1888; seventy-five thousand dollars June 1, 1889, and fifty thousand dollars October 1, 1889, the entire issue of bonds being two hundred and forty-three thousand dollars.

These bonds were redeemed upon the following dates as they became due. Of the first issue twenty thousand dollars was paid in 1896; ten thousand dollars in 1901; ten thousand dollars being unpaid, not being due until 1906. Ten thousand dollars sold October 5, 1887, was paid in full in 1897. The issue of eight thousand dollars was taken up in 1901. Of the forty thousand dollars sold September 4, 1888, thirty thousand dollars was paid in 1902, the remaining ten thousand dollars not being due until 1903. The twenty thousand dollars sold September 4, 1888, was paid in full in 1898. Of the seventy-five thousand dollars issued June 1, 1889, ten thousand dollars was paid in 1894; ten thousand dollars in 1895, ten thousand dollars in 1898 and ten thousand dollars in 1899, thirty-five thousand dollars still remaining unpaid and not yet due. The issue of fifty thousand dollars on October 1, 1889, was paid in full in 1899.

That this plant was a money-maker and a good investment for the city of Findlay is shown by the fact that, in addition to maintaining itself and redeeming its bonds, the Gas Trustees had at the time the plant was sold, an excess of seventy-five thousand dollars, which was used for the purpose of purchasing city of Findlay refunding bonds or paying special improvements and for general running expenses of the city of Findlay.

In 1896 it was decided by the Gas Trustees that the gas supply was insufficient to supply all the glass factories and other industrial plants, and thereupon the gas supply was cut off from these institutions. The meter system was adopted and the gas plant was practically devoted to supplying private citizens, who were charged twenty cents per thousand feet, which departure brought about general dissatisfaction for a time and a more economic use of the gas.

This step induced the managers of the numerous factories who had located here on account of cheap fuel to move on to new gas fields, or to some location where they could readily get a coal supply, and out of some dozen glass factories, we have but one left with us at this time, which is a large institution and has doubled its capacity since 1896. While the factory uses coal for its principal fuel, yet at certain seasons of the year when the private consumers use less gas, there is an ample supply for this purpose. While one or two of these old glass factories still stand sentinel at the outskirts of our city, most of them burned at the time of the exodus.

On February 20, 1899, this gas plant was sold by the City Council of Findlay for the sum of one hundred and fifty thousand dollars cash. The only reason

for this sale, as near as we can find out, was, "too much politics," for the major portion of the citizens were adverse to the sale and an action was brought to enjoin the consummation of it. The question of the Council's right to sell the plant was carried to the Supreme Court of Ohio, where it was decided in favor of the Council.

The receipts from the sale of this plant were used for the purchase of city of Findlay bonds and the redemption of the existing gas debt. We have now in the gas sinking fund seventy-five thousand dollars in the city of Findlay bonds, drawing interest at from 4 to 6 per cent. The company purchasing this plant immediately advanced the price of gas from twenty to twenty-five cents per thousand feet, and seemingly are not giving any better service than did the city under the trustees' management.

Altogether, the gas plant at Findlay was a very successful venture and a most fortunate investment for the citizens, as it not only maintained and paid for itself, but also helped out on other investments and improvements and left a tidy sum in the treasury besides.

Hoping that this information will be of benefit to you, I am,

Yours very truly,

WILLIAM L. DAVID.

Professor John A. Bownocker.
Columbus, Ohio.

The early history of natural gas at Findlay was in all essential respects repeated at Bowling Green and North Baltimore.

Bowling Green lies 24 miles due north of Findlay, and after gas in large volume had been discovered in the latter place it was most natural that the citizens of Bowling Green should test the underlying rocks. In January, 1885, the Bowling Green Natural Gas Company was organized, and on February 4 following work on the first well was begun.[1] The summit of the Trenton yielded very little gas, and accordingly the drill was kept at work until the rock had been penetrated to a depth of 200 feet. This, however, did not improve matters; then the well was torpedoed with 300 pounds of rack-rock, and a fine flow of gas was secured. Arrangements were at once begun to pipe the town in order that the new fuel might be put into use. Before the year closed the company had drilled all told six wells; but three only of these could be rated as producers, the last one completed yielding more gas than all others combined. Other wells were drilled with fair success, but the results all told did not meet the ambitious ideas of many citizens of the town, and accordingly the legislature was asked and granted the municipality the power to issue bonds to the amount of $25,000 to construct a municipal plant to furnish free gas to manufacturers. Drilling was at once begun and soon there was a supply adequate for all demands. The earlier wells were drilled in the main in Portage township, but later the municipality leased 500 acres in Bloom township, the richest of the Wood county territory. With a large amount of free gas offered the town began to reap the desired reward, for with such an inducement factories were easily secured. The establishments

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 156-162.

were given largely to the glass industry, and at one time over 3,000,000 cubic feet per day were used.[1]

The result of this heavy call was the quick exhaustion of the territory. In the winter of 1888-9 the supply was far from meeting the demands, and the winter following the conditions were far worse. In fact, it may be stated that the decrease in the production was as rapid as its increase had been. The story is well told by the following rock pressures:[2]

Year.	Rock pressure in lbs. per sq. inch.
1887	450
1888	375-390
1889	290
1890	100

The decrease in production was in a general way proportional to that in rock pressure, and the year 1890 saw the beginning of the end.

The first well at North Baltimore was drilled in the summer of 1886, but it produced oil rather than gas. The second well was located about one mile south of the first one, but it was still less successful. The Peters well was the first successful producer of gas secured in this vicinity. It was located about three-quarters of a mile east of the village, and had an initial flow of at least 3,000,000 cubic feet per day.[3] By 1889-90 the corporation owned three gas wells, all in the southeast quarter of Portage township. From this territory, three lines, a two-inch, three-inch and four-inch respectively were laid to the village. Funds to the amount of $8,000 to accomplish this were obtained by bonding the town. Three factories, all glass industries, were early secured; the inducement being gas for a period of ten years at a charge of five dollars each per year. Besides this the three factories received in the aggregate $24,500 in the form of donations from the town, the money having been secured from the sale of lots. A pressed brick factory also was supplied from this territory. All these establishments used the fuel in the most reckless manner; while the municipality itself and the residents of the place pursued the same wasteful policy.[4] The result was as might be guessed; complaints were soon heard of insufficient gas, and this was the beginning of the end of gas for factories. Later the fuel was restricted to domestic purposes, but this wise move was not made until the gas-rock had been almost emptied.

Bowling Green and North Baltimore were not the only places in northern Ohio that were excited by the discovery of Findlay gas. In fact, every town in that part of the state felt the effect to a greater or lesser

[1] *Geol. Sur. of Ohio*, First Ann. Rept., 1890, p. 152-4.
[2] *Ibid*, p. 155.
[3] *Ibid*, Vol. VI, p. 227-9.
[4] *Ibid*, First Ann. Rept., 1890, p. 140-1.

extent, and companies were quickly formed to test the underlying rocks with the hope of finding the fuel that produced such remarkable events. The results were in most cases disappointing, but the courses taken by the municipalities form an interesting chapter in our state's history. An outline only of this can be given here. A deep well was drilled at Toledo in 1885, and a number of others were put down shortly afterwards in different parts of the county. The most that can be said for these is that they made a showing of gas, but in 1887 the new fuel was piped to the city from Wood county by two companies; the Northwestern Ohio Natural Gas Company and the Toledo Natural Gas Company. The city council fixed the maximum rates that the companies could charge, and it was expected that competition would work to the city's interest, but the two companies did not engage in a contest similar to that which took place at Findlay. In fact, after a short time, they pooled their interests.[1] While the rates charged were not unreasonable no special inducements, such as free gas, were made to factories. In other words, these companies looked after their own interests rather than those of local real estate men. The result was that Toledo did not experience the boom that the smaller cities to the south enjoyed, and in 1888 a petition was presented to the legislature praying for the power on the part of Toledo to construct and operate a natural gas plant of its own. The bill did not pass at this session, however, but a year later received a large majority in each house. The act was ratified by a vote of the citizens in April, 1889, and the city council speedily authorized the sale of $75,000 worth of bonds. The gas trustees at once began leasing territory in Wood and Hancock counties, paying a large annual rental thereon. On this wells were drilled. In addition the trustees contracted with the Stuartsville Land Association to furnish them with 50,000,000 cubic feet of gas per day, the trustees to purchase the wells producing this gas at $1,000 for every million cubic feet of gas which they produced when purchased. Each well was to have on the average ten acres of land to draw on. Contracts of a similar nature were made with other parties.

When the bonds referred to above were advertised for sale, the Northwestern Ohio Natural Gas Company, a branch of the Standard Oil Company, entered the United States court, asking for an injunction against the sale of bonds, but the municipality won an easy victory. Late in the same year (1889) the company again brought suit, but the gas trustees were again victorious. The money derived from the first sale of bonds was speedily exhausted, and the trustees then offered for sale the remainder provided for by the special act of the legislature, amounting to $675,000. One hundred thousand dollars' worth were taken by citizens of Toledo, but the remaining ones found no buyers. This was regarded as a result of the attack made by the Standard Oil Company, which seems

[1] *Geol. Sur. of Ohio*, First Ann. Rept., 1890, p. 146-151.

to have prejudiced the bonds in the eyes of the capitalists that were expected to buy them.

The following interesting account of this plant was furnished by Mr. Robert Campbell. It is published in full, even though it repeats part of what has already been said:

"After gas had been discovered in Hancock and Wood counties, Ohio, investors from nearby towns and cities, including Toledo, became interested in territory of greater or less value. During 1887 and 1888 the towns of Findlay, Fostoria and Bowling Green were enjoying booms due to the fact that free gas for fuel was offered at these places as a bonus to manufacturers; but at Toledo no such offer could be made because the gas was furnished by a private corporation, The Northwestern Ohio Natural Gas Company. Even though the Northwestern offered to enter into a contract to furnish natural gas for five years at the very low rate of 12 cents per thousand cubic feet, still some of the Toledo investors in gas territory and their associates, the men who wished to reap a harvest of money by a boom advance in the values of real estate in and about Toledo, began in 1888 to agitate the municipal ownership of a natural gas plant.

"So successful was this agitation that in January, 1889, in reply to a petition from citizens of Toledo, the General Assembly of Ohio passed an act, subject to the decision of the electors of Toledo as expressed at the polls in April, providing that the Governor should appoint a board of trustees to conduct the work of securing and maintaining a natural gas plant as soon as the necessary funds were obtained by the sale of city bonds issued expressly for that purpose. During the months previous to the day for voting either for or against the act the strife between the parties favoring or disapproving the project became heated, and every inducement was offered to secure the vote of even the least interested electors. 'Free gas' was the hosanna cried to the poor, while to others assurance was given by these promoters that the gas plant would pay for itself in five years, clear away the municipal debt in another five, and pay the expense of city government and improvements thereafter. As was to be expected, the poor and non-taxpaying residents, who had everything to gain and nothing to lose, rushed to the polls and overwhelmed the vote of the tax payers, who were almost without exception opposed to the project.

"In accordance with the provisions of the act it now became the duty of the Governor to appoint a board of trustees, which was duly organized and began at once to negotiate for gas wells and territory. Naturally enough the territory most easily secured was the less valuable of the property of the investors who were promoting the scheme, for these men had no scruples about selling to the city their 'high pressure' wells as 2,000,000 cubic feet producers, whereas in reality the well was only a 50,000 cubic feet producer with almost no pressure at all.

"Later in the summer of 1889 an issue of bonds for $500,000 was advertised. This announcement called forth into open battle a determined antagonist, the Standard Oil Company. By its agents injunction suits, based upon the alleged unconstitutionality of the act passed by the General Assembly, were filed both in the state and federal courts. The city won the case in both courts; still the Standard Oil Company caused circulars to be sent to dealers and investors in municipal bonds both in the United States and Europe, warning them against the purchase of the bonds as being illegal and void and issued under an act that was unconstitutional, giving notice that suits had been commenced in the courts. Furthermore, the movements of the trustees, or anyone authorized to sell the bonds, were so closely watched by spies, that whenever a trip was made to an eastern or western city by any of these men it was soon discovered that the enemy had preceded in order to close the ears of purchasers and their pocket-books as well. In the field the opposition of the Standard Oil Company was still more troublesome, for the agents of that corporation left no territory unvisited, and in certain localities favoring the Toledo enterprise even represented themselves as members of the board of trustees or as the president himself. Because of the unlimited capital of their corporation the agents advanced the price of rentals on undeveloped territory as much as 1000 per cent.; and land formerly worth 25 cents an acre per annum for gas rental could not be secured for less than $10 or even $20 an acre by the Toledo trustees. Altogether the loss to the city, due largely to the opposition of the Standard Oil Company in the matter of bonds and of purchasing territory, has been estimated at more than a million dollars.

"Notwithstanding all their troubles the trustees were finally able to secure natural gas, to construct a main line from the field, and to plant distributing pipes throughout the city. The supply of gas, however, soon became a vexatious problem, for at no time in winter was there enough gas to accommodate all consumers. The manufacturing plants were the first to have their connections removed, but even then the patrons at a short distance from the main line suffered during the severe weather, while those on the outskirts had no gas at all. To relieve this condition the General Assembly was petitioned in 1892 to pass the necessary legislation to allow the city to issue bonds to the amount of $100,000 to meet the cost of bettering the gas plant and to secure a pumping station for the (Stuartsville) field. As soon as this work was completed and other pumps were introduced into the line the trustees were able to give fair satisfaction to the consumer until 1896.

"To provide for the great expense of securing natural gas and of constructing the gas plant, the city had sold from time to time the various issues of bonds here tabulated:

Amount.	Date issued.	Due.	Rate.	Interest.
$ 75,000.00....	May 10, 1889	May 10, 1919..	4½ %..	$ 3,375.00
100,000.00.....	Oct. 1, 1889	Oct, 1, 1899..	4½ ..	4,500.00
100,000.00.....	Oct. 1, 1889	Oct. 1, 1904..	4½ ..	4,500.00
150,000.00.....	Oct. 1, 1889	Oct. 1, 1909..	4½ ..	6,750.00
150,000.00.....	Oct. 1, 1889	Oct. 1, 1914..	4½ ..	6,750.00
175,000.00.....	Oct. 1, 1889	Oct. 1, 1919..	4½ ..	7.875.00
100,000.00.....	July 1, 1892	July 1, 1917..	4½ ..	4,500.00
300,000.00.....	Oct. 2, 1893	Oct. 2, 1903..	4½ ..	13,500.00
$1,150,000.00				

"In return for this expenditure of $1,150,000 the gas plant has paid from its earnings only $100,000 in dividends to the city. This money was used each year to pay a part of the interest on the bonds:

		Totals.
Sept. 3, 1892.....		$ 20,000.00
May 27, 1893.....	$20,000	
Oct. 24, 1893.....	10,000	
Dec. 30, 1893.....	10,000	
		40,000.00
Mar. 19, 1894.....	15,000	
Oct. 15, 1894.....	10,000	
		25,000.00
Mar. 26, 1895.....	10,000	
Apr. 3, 1895.....	5,000	
		15,000.00
		$100,000.00

"Thus it was that the statements of January 1st, 1896, showed an invested debt of more than a million dollars not even paying the interest on the bonds outstanding.

"The winter of 1896 disclosed no untouched resources; rather, in fact, the supply of gas again became noticeably deficient. Later in the year, however, new territory in Ottawa county, Ohio, was developed, and from this field a pipe line was constructed to the city, so that the gas was turned on with satisfactory results in February, 1897. But in another year the supply became less and less sufficient; with the inevitable result that the municipal gas plant soon lost nearly all its patrons and maintained only a desultory existence through 1898 and 1899. Finally in the latter year all that part of the gas plant outside of the limits of the city of Toledo (including territory loaned and leased, pumping stations, pipe lines, telephone lines, etc.) was sold to the Kerlin Brothers for $102,000. As the city then had no gas to supply its lines the trustees entered into a contract with the Kerlin Brothers Company for a supply at twenty cents per 1,000 cubic feet. Under this contract gas was furnished the city until January 1st, 1901, when the supply was discontinued.

"By the receipt of $102,000 for the outside portion of the gas plant the city was able to pay the only issue of bonds that have become due, $100,000, on October 1, 1899. Some months later the distributing lines inside the city were leased to the Toledo Gas-Light & Coke Company for the insufficient sum of $6,500 a year. And this annual income of $6,500 is all the returns that the city of Toledo receives for its expenditure of two million of dollars to establish a municipal gas plant—the grand spectacle of a magnificent failure.

"Today (January 1, 1903) the natural gas used in Toledo is furnished by the Northwestern Ohio Natural Gas Company (controlled by the Standard Oil Company), who secure it from the fields of Fairfield and Hocking counties, Ohio. This supply is obtained from the Clinton formation and is sufficient for all normal occasions; on extremely cold days, however, the small quantity still obtained in the Wood and Hancock county fields is turned into the mains leading to Toledo, so that even at the present time some gas is secured from the Trenton rock of Ohio. The latter formation also furnished the supply of the municipal gas plant as long as it continued in operation. The cost of the fuel has steadily advanced from 12 cents per 1000 cubic feet in 1888 to 30 cents in 1903."

Fostoria, lying a short distance northeast of Findlay, drilled a test well in the summer of 1885, but this was a failure, though it made a showing of both oil and gas.[1]

Another well was drilled a year later. After having been shot with a heavy charge of nitro-glycerine it made a fair showing of both oil and gas, but neither in commercial quantity. A third well was drilled west of the city but without noteworthy success. Encouraged by these failures the Northwestern Ohio Natural Gas Company piped the city, giving the inhabitants their first experience with natural gas. This, however, did not boom the place, and to accomplish this free gas was necessary. Accordingly the legislature was asked and granted the municipality the right to issue bonds to the amount of $35,000 to lease territory, drill wells, lay pipe, etc. Public-spirited citizens raised $25,000 additional to assist in the work. The territory leased lay principally in the townships west of the city. This commanded a high rental, adding materially to the city's expense. An ample quantity of gas was soon secured, and the city at once began to feel the desired wave of prosperity. As in other gas towns, glass became the principal industry, but the fuel was used for numerous other purposes. Dr. Orton estimated the quantity of gas used by these factories to have been at least 7,000,000 cubic feet per day.[2]

Tiffin's experience was similar to that of Fostoria. The first well reached the Trenton in January, 1886, and yielded a small quantity of oil and gas as well as salt-water. The result here was merely sufficient to

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 192-3. [2] *Ibid*, First Ann. Rept., 1890, p. 190-2.

insure further exploration, and a second well reached the Trenton in October of the same year.[1] This yielded both oil and gas in small quantities, and should be classed as an oil well. Other wells were drilled with similar results, and by 1888 the citizens of Tiffin had reached the conclusion that they must look elsewhere for their gas supply. A branch of the Northwestern Ohio Natural Gas Company had already entered the city and was supplying gas to residences and factories, but here again the company was looking after its own interests rather than those of Tiffin. The usual result followed—an agitation for a municipal natural gas plant to furnish free or practically free gas to factories. The legislature granted the city the authority to issue bonds, and the gas trustees purchased, at an exorbitant rate, the gas rights on lands in Wood county.[2] By 1890 the city had expended over a quarter of a million of dollars on this enterprise, and since the gas was furnished free to factories it is apparent that the income to the city was very small. However, free fuel secured the desired manufacturing establishments, and consequently the city secured indirectly what it could not directly.

Several towns or cities which had failed to secure gas in the underlying rocks, and which did not drill wells and pipe the gas from a distance, were supplied by the Northwestern Ohio Natural Gas Company to which reference has already been made several times. This corporation supported as it was by the great resources of the Standard Oil Company, was able to work on a scale which no other company could do. Very early in the history of the field it secured the best territory in Wood and Hancock counties on relatively easy terms. This it developed in the best manner known, and piped the fuel as far north as Detroit, and as far east as Sandusky. As a rule the rates charged did not permit the fuel's use in factories, and this of course, extended the duration of the supply.

Besides the places named a number of much smaller towns and villages in Hancock, Wood, Sandusky, Seneca and Ottawa counties have enjoyed natural gas. This has usually been derived from small wells close at hand, and since the quantity was not adequate to attract factories the life of the wells has been greatly extended.

PRESENT CONDITION OF THE TERRITORY REVIEWED.

This can be stated in a few words. The early failure of gas at Findlay has already been noted. Leasing territory and drilling wells in the northern part of the county renewed the supply, but only postponed for a brief period the fatal day when gas for everybody and all purposes must end. Early in the nineties the larger factories could no longer be supplied; next the smaller ones were dropped, and at present the use of the fuel is restricted to domestic purposes.

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[1] *Geol. Sur. of Ohio*, Vol. VI, p. 197-201.

[2] *Ibid*, First Ann. Rept., 1890, p. 186-190.

From 1887 to 1889 a large number of manufacturing industries were induced by offers of free gas to locate at Findlay. These included fourteen glass houses and several iron and steel works. A large number of the glass factories were absorbed by the United States Glass Company, and then abandoned when the gas supply became inadequate. Two factories burned and were not rebuilt. At least four abandoned their plants, and rebuilt in Indiana where gas was more abundant. With several exceptions these glass companies had little or no capital, but were dependent on the bonuses furnished by the town for the capital necessary to run their plants. With the failure of gas these companies were left practically bankrupt.

The Wetherald Rolling Company which had come with the boom, left for Indiana in 1892. It employed 200 men. The Salem Wire Nail Company, employing 300 men, sold out to the American Wire Nail Company, but the plant burned and was not rebuilt. Rounds Chain Works, the Ohio Lantern Factory, the American Nail Machine Company, and a number of smaller establishments abandoned their works because of the failure of gas.

The suply of gas in 1902 was derived principally from Cass and Marion townships, one of which lies east and the other north of Findlay, but a few wells are scattered over two or three other townships. The number of wells on which the city relied during the summer of 1902 was about 85. Others are drilled from time to time, and in this manner the supply is maintained. Probably the very best wells now drilled do not have an open flow exceeding 1,000,000 cubic feet per day, while the available supply is only a fraction of that. It is entirely safe to state that less than a half dozen of the large wells of 15 years ago would more than balance the 85 which now reluctantly yield a scant supply. Besides the Findlay wells, the Kenton Gas & Electric Company has 18 wells in Jackson township, and the Northwestern Ohio Natural Gas Company has a small number scattered over the county.

Wood county duplicated Hancock's record. As has already been stated the rock pressure at Bowling Green had fallen to 100 pounds per square inch in 1890, and that marked the end of gas in large volume for that part of the territory. The great Bloom township field lasted longer, largely because it was in the control of a corporation which well knew the limited supply and used all methods to prolong the life. Such cities as Fostoria and Tiffin soon found themselves with a supply totally inadequate to meet the demands of the industries which had been attracted to them by the offer of free gas. Later the great Northwestern Ohio Natural Gas Company also met the same fate. In 1902 this corporation still had about 45 wells in Wood and Hancock counties, but the fuel obtained was barely sufficient to supply power for two pumping stations of the Buckeye Pipe Line Company. At the time mentioned the only villages supplied with gas

from Wood county were Bairdstown and Bloomdale. To such proportions have the great Hancock-Wood county gas fields shrunk!

Among villages in adjacent counties that still have an adequate supply, in whole or in part, may be mentioned Oak Harbor and Genoa in Ottawa county; Gibsonburg and Burgoon in Sandusky county; Kansas in Seneca county. Doubtless this list might be enlarged, but the quantity of fuel consumed in this manner is small.

THE ST. MARYS NATURAL GAS FIELD.

On July 26, 1886, a well was completed at St. Marys, Auglaize county, the result being a small flow of both oil and gas. The well was torpedoed later and the production increased, but the most that can be said for this test was that it demonstrated the presence of the desired fuel. The second well was a total failure, but the third one produced sufficient oil to warrant rigging for this material.[1] Early in 1887 valuable gas wells began to be found, the first of which located on the Axe farm was completed March 23, and three weeks later had an open flow exceeding 2,000,000 cubic feet per day. Other wells were completed with similar results. The rock pressure of the field was about 350 pounds per square inch. St. Marys township contained the best territory, but small areas in the adjoining townships of Washington and German also yielded gas.

From Auglaize county the belt extended southwest into Mercer, including parts of Franklin, Marion and Granville townships. The first named township contained the best wells, the largest of which had an initial open flow of 10,000,000 cubic feet in 24 hours. It is doubtful if this figure was exceeded anywhere in what is here called the St. Marys field. It appears, in fact, from data obtained at this late day that wells exceeding one-half the figure just given were rare. This field extended northeast and southwest, its length being nearly 20 miles. Work in Mercer county began in 1886, the first well having been drilled at Celina. This made merely a show of oil and gas, and a second well completed a few weeks later gave still less encouragement. In November, 1886, a well was completed near St. Henry, Granville township. and when measured about four months later was flowing over 2,600,000 cubic feet per day. Early in 1887 a well was completed on the Doenzes farm in Franklin township with still more favorable results, the production exceeding 4,600,000 cubic feet in 24 hours.[2] With such results work progressed rapidly, and the quantity of fuel secured was such as to warrant laying lines to adjacent cities and towns.

The history of the field from this point was similar to that around Findlay. However, the wells were smaller, and consequently there was less opportunity for the excitement and speculation that prevailed farther

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 254-8.
[2] *Ibid*, p. 258-62.

northeast. Perhaps, too, the experience gained in that territory had a sobering effect in this.

By authority of the legislature, St. Marys was permitted to bond itself for $32,000 to construct and operate a natural gas plant. A block of 1,100 acres lying near the town was leased at a low rental, and a number of good wells secured. Fuel was supplied for domestic purposes at one dollar a fire per month, and two factories were supplied without charge.[1] According to data furnished by J. D. Simpkins, Superintendent of Schools, the town incurred an indebtedness of $24,000, and this was subsequently paid by receipts from the sale of the plant. The place discontinued the use of natural gas from the Trenton of Ohio, in 1893.

The Lima Natural Gas Company derived its principal supply of gas from St. Marys township, where it had about 7,000 acres of land leased. The company began piping gas to Lima in 1887 and for a short period had an ample supply, but the flow decreased gradually and gave out entirely in 1894. Since then the fuel has been obtained from Indiana. In the fall of 1902 the rate was 25 cents net per thousand cubic feet, but if the consumer furnished the meter the rate was five cents lower.

A number of wells drilled in the vicinity of Van Wert promised so well that a line was laid to the town in 1888. However the supply was not up to expectations, and after $50,000 had been expended in making tests, the trustees leased territory in Franklin township, Mercer county, and laid a line to Van Wert, 31 miles away. Good wells were secured, and soon the town had an adequate supply. When this territory gave out the trustees again devoted their energy to developing gas lands in their own county. At the present time (August, 1902) the supply is derived from six wells in Ridge township. The first of these was drilled in 1894, and other wells have been put down from time to time since that year. In April, 1902, the total open flow of the wells was reported at over 2,800,000 cubic feet per day. The rates charged for the fuel are 25 cents per thousand, if paid before the 10th of the month, after that 30 cents. The company pays the landholders a royalty of $50 a year for each well.

In 1888 the Wapakoneta Natural Gas Company was organized, its object being to supply that town with fuel in order that it might not be at a disadvantage with neighboring places. The plant was constructed and operated by citizens of Wapakoneta, who leased territory in St. Marys and Washington townships. Owing to the late day at which the wells were drilled, the rock pressure was comparatively low at the start, and this of course diminished the life of the wells.[2] Besides the places named a number of smaller towns and villages were supplied from this field.

Celina, the county seat of Mercer county, was supplied by the Celina Light & Fuel Company, whose territory lay chiefly in Franklin township,

[1] *Geol. Sur. of Ohio*, First Ann. Rept., 1890, p. 157.

[2] *Ibid*, Vol. VI, p. 160-1.

Mercer county. The fuel was used for domestic purposes, and also for factories, the principal industry being glass.

While the company was a private affair, an arrangement was made between it and the city council by which free gas was to be furnished for the two glass houses during a period of five years. The result of the heavy demands was the cry insufficient gas, the rock pressure of the field having fallen from 390 pounds in 1887 to 240 in June, 1890.[1]

The Mercer Natural Gas Company was by far the largest one operating in Mercer county. Its principal territory lay in Franklin township, but it had wells in Auglaize county as well as in Mercer. The company's lines supplied Sidney, Piqua, Troy, Springfield, Dayton, and a number of smaller places. It is hardly necessary to state that this corporation did not furnish free gas to factories, and consequently that the places named did not enjoy the boom that Findlay and adjacent towns did. The fuel was used economically and its life prolonged to the farthest limit. It is interesting to note in this connection that these places are now, in part at least, supplied from the Sugar Grove field, a line having been laid from that territory to Springfield, where it connects with the old lines of the Mercer Natural Gas Company.

The city of Urbana, anxious to enjoy the prosperity that seemed to follow free gas, began by testing the Trenton limestone in that vicinity, and finding it barren of the desired fuel, turned to the territory in Auglaize and Mercer counties. The course from this time was of the usual nature; the legislature passed an act (1889) permitting the citizens to vote on a proposition to bond the municipality for a quarter of a million of dollars to lease territory, drill wells, lay mains, etc. The proposition appealed to all, for out of a vote of 1,240 only 27 were recorded against it.[2]

Lands were leased in Marion township, Mercer county, and the trustees soon had a fine supply of fuel. However, the town did not enjoy the manufacturing boom that it had looked for. This resulted from several causes: (1) The late date (1890) at which the city was prepared to furnish gas; (2) the remoteness of the producing territory; (3) the demonstrated brief life of gas wells. However, the municipality was supplied for several years with the best fuel known, and later when its territory gave out, the lines were filled from the Sugar Grove field. The later history of natural gas in Urbana is given below; the data having been supplied by I. N. Keyser, Superintendent of Schools:

"The city of Urbana was bonded for $250,000 to make the necessary preparations to supply gas. The supply was derived from the St. Marys field, and at first the pressure was sufficient to yield a good flow. After four years the field pressure ran down so that it could no longer force the

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 162-4.
[2] *Ibid*, p. 166-70.

gas to Urbana—47 miles distant—and then pumping stations were constructed. This prolonged the life of the plant four years longer, and by that time the supply was so small that the territory was abandoned.

"The plant was leased and later connections were made with the Sugar Grove field which now furnishes the town fuel at 25 cents per thousand cubic feet.

"The income from the plant was not sufficient to pay off the bonds entirely, so a sinking fund was established and the debt rests easily.

"The gas was piped to Urbana in 1890, when experience was limited in matters of gas well permanency. Then, too, the trustees desired to furnish gas as cheaply as possible, fixing the price at 11 cents per thousand cubic feet. Later this was increased to 15 cents, and when the plant was leased the price was first fixed at 20 cents and now (December, 1902) is 25 cents.

"Had the value of the fuel been thoroughly appreciated at first and the price set at 20 or 25 cents, I doubt not that the city ownership would have been profitable. As it is, what money was spent to make up deficits is money, in part, that was saved by cheap fuel."

Greenville, Darke county, proceeded in a manner similar to Urbana. Under authority of the legislature the town bonded itself for $130,000 to procure and operate a natural gas plant.[1] Previous to this a company had leased a tract approximating 1,200 acres in Granville township, Mercer county, and drilled two wells on it. The trustees of the new plant bought this property and drilled additional wells with fair success. A line 19 miles in length was laid to the town, and soon there were 2,000 fires supplied with the new fuel. The gas was used on a small scale for factories, the largest consumer having been a tile mill.

THE DISCOVERY AND DEVELOPMENT OF THE OIL FIELDS IN NORTHWESTERN OHIO.

It is seen from what has already been said that the pioneer deep wells in northwestern Ohio had for their object natural gas, oil having been an incidental product, and since it obstructed the flow of gas through the lines, was at first looked upon with disfavor.

The oil industry in this part of the state had its beginning in the autumn of 1885. It is difficult to decide which county should have the credit of the first oil well, since many produced both oil and gas, the relative quantities being such that some call them oil wells while others class them with gas wells.

Allen county was the third to test the Trenton limestone, and like the earlier work in Hancock and Wood counties the object was natural gas. The well was located at Lima, and was completed April 1, 1885. When the Trenton rock was struck it yielded little or no gas, but in its stead a

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 170-2.

small quantity of oil—a great disappointment to the parties interested. After having been shot with rack-rock the well was pumped, yielding about 18 barrels of oil per day.[1] The product was looked upon with much disfavor because of its density, color, and particularly its odor. The great fields of Pennsylvania were in sandstone, while the oil in question was derived from a limestone, thus further prejudicing the new field. However the interested parties did not cease work even if the product was apparently of very low quality, and in the fall of 1885 completed a well which had for its object testing the underlying rocks with reference to oil production. When put to pumping it yielded forty or more barrels per day, and during the early months of 1886 averaged 26 barrels each 24 hours. Oil from this well was sent to large refineries, and the results of tests made gave great encouragement to the producers. This really marks the beginning of the industry in Allen county. Not until the following year, however, was any considerable progress made in the development of the territory.

As has already been stated gas was discovered at Findlay in November 1884, and though the flow was small it was adequate to make certain further tests. Almost from the start oil appeared in these wells, but in very small quantities. Well No. 4, completed May 28, 1885, was the first one drilled in this field that may be classed as an oil rather than a gas well. At first, however, it produced over a million cubic feet of gas per day, but during the closing months of 1885 it flowed about five barrels of oil each 24 hours.[2] In January, 1886, the production of gas dropped suddenly, owing to the influence of the Karg well, and at the same time the yield of oil increased from five to fifteen or more barrels per day. Well No. 8, completed November 6, 1885, was drilled primarily for oil, the first one sunk for this purpose in the county. The Trenton was struck at 1,265 feet, and drilling continued until a depth of 1,320 feet had been reached. The well was then shot with 100 quarts of nitro-glycerine, and began flowing oil at the rate of 300 barrels per day. The production decreased rapidly to 35 barrels per day.[3] Dr. Orton considered this the first of the oil wells in Hancock county, and that the petroleum industry in that territory began with this.

In the summer of 1886 a well was drilled at North Baltimore, Wood county, the object being, as in all these pioneer wells, natural gas. At seventeen and one-half feet in the Trenton, oil was found. After having been shot with 40 quarts of nitro-glycerine, the well was tubed, and began flowing from 12 to 15 barrels of oil per day. In a short time, however, the production decreased greatly and then the well was abandoned. The oil was lighter (41 degrees B.) than that found at Lima, and this encour-

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 166.
[2] *Ibid*, p. 122-4.
[3] *Ibid*, p. 126.

aged the producers to such an extent that they began leasing territory in the vicinity of North Baltimore with reference to the development of an oil field. Later in the year a number of fine wells were secured in the same township (Henry), and from that period rapid progress was made.[1]

The year 1885 demonstrated the existence of oil in the Trenton, and in the ensuing year development began rapidly. From the established centers the drill moved out in all directions, and during the same time much testing of the "wild-cat" type was done. The result was that in a short period the important fields had been outlined, and by far the greater part of the work done since has been in developing that territory.

The following statistics, compiled from the Mineral Resources of the United States, tell plainly the growth of the industry.

Production of the Trenton Limestone in Ohio from 1886 to 1901.

Year.	Barrels.
1886	1,064,025
1887	4,650,375
1888	9,682,683
1889	12,153,189
1890	15,014,882
1891	17,315,978
1892	15,169,507
1893	13,646,804
1894	13,607,844
1895	15,850,609
1896	20,575,138
1897	18,682,677
1898	16,590,416
1899	16,377,174
1900	16,884,358
1901	16,176,293

The production in 1885 was comparatively small.

The following table gives the annual output of the United States from the biginning of the industry in 1859 to 1901, and that of Ohio beginning with 1876.

Production of Oil in Ohio and the United States from 1860 to 1901.[2]

(Barrels of 42 Gallons.)

Year.	Ohio.	United States.	Year.	Ohio.	United States.
1859	.....	2,000	1881	33,867	27,661,238
1860	.....	500,000	1882	39,761	30,510,830
1861	.....	2,113,609	1883	47,632	23,449,633
1862	.....	3,056,690	1884	90,081	24,218,438
1863	.....	2,611,309	1885	661,580	21,858,785
1864	.....	2,116,109	1886	1;782,970	28,064,841
1865	.....	2,497,700	1887	5,022,632	28,283,483
1866	.....	3,597,700	1888	10,010,868	27,612,025
1867	.....	3,347,300	1889	12,471,466	35,163,512
1868	.....	3,646,117	1890	16,124,656	45,823,572
1869	.....	4,215,000	1891	17,740,301	54,292,655
1870	.....	5,260,745	1892	16,362,921	50,509,657
1871	.....	5,205,234	1893	16,249,769	48,431,066
1872	.....	6,293,194	1894	16,792,154	49,344,516
1873	.....	9,893,786	1895	19,545,233	52,892,276
1874	.....	10,926,945	1896	23,941,169	60,960,361
1875	.....	12,162,514	1897	21,560,515	60,475,516
1876	31,763	9,132,669	1898	18,738,708	55,364,233
1877	29,888	13,350,363	1899	21,142,108	57,070,850
1878	38,179	15,396,868	1900	22,362,730	63,362,704
1879	29,112	19,914,146	1901	21,648,083	69,389,194
1880	38,940	26,286,123			

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 227-8.

[2] Note.—The production given for the United States for the year 1875 includes all prior to 1876 in Ohio, West Virginia and California.

The Following Table Gives the Quantity and Value of Oil of the Three Producing Areas in Ohio from 1895 to 1901.

Year.	Northwestern Ohio.		Southeastern Ohio.		Mecca-Belden.		Total.	
	Product (bbl.)	Value.	Product (bbl.)	Value.	Prod.(bbl.)	Value.	Product (bbl.)	Value.
1895	15,850,609	$11,372,812	3,693,248	$5,018,201	1,376	$ 8,229	19,545,233	$16,389,242
1896	20,575,138	13,723,617	3,365,365	3,966,924	666	2,897	23,941,169	17,693,438
1897	18,683,677	8,967,685	2,877,193	2,262,193	645	3,120	21,560,515	11,232,998
1898	16,590,416	10,244,582	2,147,610	1,957,010	682	3,618	18,738,708	12,205,210
1899	16,377,174	14,718,985	4,764,135	6,243,075	799	4,244	21,142,108	20,966,304
1900	16,884,358	16,673,304	5,476,089	7,406,734	2,283	11,563	22,362,730	24,091,601
1901	16,176,293	13,911,612	5,470,850	6,619,343	940	2,617	21,648,083	20,533,571

WOOD COUNTY.

This has the largest area of oil producing territory of any county in the state. It includes two extensive belts; one on the eastern, the other on the western side of the county, but in the southern part the two are connected by a narrow strip. The western area is the larger; in fact it is the most extensive pool that has been or ever will be found in Ohio. Continuing south it enters Hancock county, where it covers a large area. The eastern belt extends into Sandusky county and the northwestern corner of Seneca. Probably no other county in the state has had so many deep wells drilled in it as Wood. Almost every section has had at least one test made on it, and on some they may be counted by the score. This has demonstrated the parts that contain oil, and it may be that with higher prices for the crude product, territory which cannot now be regarded as productive may become of value; just as some territory, which was not regarded worth developing fifteen years ago, is now highly prized..

Next the several townships will be considered in detail, taking first those on the western side of the county, and later those on the eastern.

Middleton Township.—The oil fields in this township form a strip from one-quarter to a mile in width, which runs nearly due north and south through "river tract sections" 46, 47, 48, 49, 50 and 51; and sections 14, 15, 21, 22, 23, 26, 27, 33, 34 and 35.

An effort was made in the summer of 1902 to extend the arm farther north in this township, but without success; a well on the "river tract" section 52 was dry, and the same is true of a well drilled about three miles farther north.

In the eastern part of Middleton there is a small pool of oil, now nearly exhausted. Formerly it extended from the northern half of section 28 through 21 and 16, and then into Perrysburg township, where it crossed section 33. Now (1902) it consists of two parts; a small pool about one-quarter of a mile square in the northern part of section 28 and a larger one extending northward from near the center of section 21. The territory connecting these two spots was much less productive than the other parts, and this accounts for its comparatively early abandonment. The pool is commonly spoken of as the Dunbridge or Dowling, since it lies near these villages.

Previous to 1890 very little drilling had been done in this township. Test wells sunk about that time in the vicinity of Haskins gave much promise, and consequently rapid progress was made in the development of the pool. Wells now (1902) rarely have a larger production than 10 barrels per day, and the average is only a small fraction of that. Very few are being drilled, and while the number abandoned thus far is small, it will be large in the near future.

The Dowling pool was opened in 1894-5, and at first was regarded as very promising, though the oil was of poor quality. The number of wells

in 1896 was 57 and the combined daily production 350 barrels; in 1902 the number was 86 with a production of only 75 barrels, an average of less than one barrel per well. The pool is rapidly approaching extinction. The gravity of the oil in 1902 was 34 degrees B.

Washington Township.—The only oil territory in this township is found in the extreme northeast corner, and does not exceed 80 acres. This is part of a small spur which leaves the strip in Middleton township, near the village Haskins.

Plain Township.—From Middleton the strip extends south into Plain township where it occupies parts of sections 2, 3, 10, 11, 14, 15, 16, 17, 21, 22, 23, 25, 26, 27, 28, 32, 33, 34, 35 and 36. In the northern part of the township the strip is very narrow, not exceeding in places one-quarter of a mile, but along the southern line it exceeds three miles. The broad portion of the territory encloses a non-productive strip nearly three miles in length, and from one-quarter to one mile in width. Enclosures of this type are common in Wood and Sandusky counties. The entire area of producing territory in this township does not exceed eight square miles.

In 1890 Dr. Orton predicted that an oil field would be developed west of Bowling Green, though at that time the nearest wells were in the southern part of the township, and near Haskins in the township to the north. The terrace extending north from Findlay had been located west of Bowling Green in the county now under consideration, and on this basis oil was predicted. Wells were drilled in this region in 1890-1 with favorable results, and continued progress has been made since. But few wells have been drilled in recent years, and naturally the production is decreasing.

Liberty Township.—A large part of this township is productive. The territory enters as a broad belt from Plain and continues due south across the township, including the whole or parts of sections 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 33, 34, 35 and 36, and having an area of about 22 square miles. In the northwestern corner of the township there is an unproductive area. This extends southeast from section 2 through 1, 11, 12, 13, 24 and 25, and then enters Portage township. The barren strip is completely surrounded by oil territory, and has been frequently tested, the result being salt-water and a small quantity of oil.

In 1890 the eastern sections of the township were being rapidly developed, but the presence of a large reservoir of salt-water seemed to cut off production further west. Later, however, it was found that the water could be controlled, and then the condemned territory began to be drilled. This has since demonstrated itself to be one of the most valuable parts of the county.

Henry Township.—From Liberty the producing territory extends south entirely across the township under consideration and then continues into Hancock county. In the northern part of the township the territory

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is three miles wide and this dimension continues south of the middle of the township where two enclosed non-productive areas are found. The sections producing oil include the whole or part of 1, 2, 3, 4. 9, 10, 11, 12, 13, 14, 15, 16, 21, 22, 23, 24, 25, 26, 27, 28, 33, 34 and 35.

As has already been stated this was the first territory developed in Wood county. Since 1890 the outlines of the producing areas have undergone little change, and the large amount of drilling done since that time has been to develop these areas. However development in this direction has reached its limit, and the time when the township will cease to be included in the oil fields will be determined by the duration of wells already drilled.

Portage Township.—The oil territory in this township connects the two larger pools of Wood county, as is plainly shown on the map. The most striking feature is the barren tracts enclosed or partly enclosed by producing territory. The productive area includes the whole or parts of sections 6, 7, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, but while the area is scattered over the larger part of the township, it does not exceed ten square miles.

The time of the development of the township was similar to that of Bloom, though apparently a little earlier. The barren tracts have been thoroughly tested, but give no promise of becoming productive territory. A few wells are still (1902) being drilled in the township, some of the best having been secured on lots in the village Portage.

Bloom Township.—This township, lying east of Henry and south of Portage, contains part of the pool found in the western half of Wood county. The productive territory lies on the west side of the township, and is very irregular in outline. It includes the whole or parts of sections 4, 5, 6, 7, 8, 9, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 31, 32, 33, 34, 35. Besides this a small pool of perhaps 60 acres is found in section 36 in the extreme southeast corner of the township.

Formerly Bloom township was the center of the natural gas industry in Wood county. When the flow of gas became weak, oil appeared, and in this manner some gas wells became producer of oil. Later the territory was re-drilled, this time with oil in view. In 1890 the number of oil wells in the township was small, but a little later the Henry township field was extended into the western margin, and the Portage township field into the northern margin, and thereafter the territory was rapidly developed. During the past year (1902) the principal development was in the southern part of the township near the villages Welker and Bairdstown.

Webster Township. —In 1902 there was only one pool of oil in this township. This had an area of only 100 acres and was situated in the northeast corner of section 22 and the southeast of 15. As may be seen from the map the pool is close to the Dowling, to which the quality of oil is similar.

Troy Township.—Oil territory in this township is small, and is confined principally to the southeast quarter, where it occupies parts of sections 23, 24, 25, 26 and 36. The area of this is about two square miles. It is an extension of the pool lying in the vicinity of Woodville, Sandusky county.

In the northwest quarter of section 12 a very small pool exists. It consisted in 1902 of five wells running in a northwest and southeast line. Another well or two has been drilled in this vicinity with a small degree of success.

Territory in this township began to be developed in 1894-5. The small pool in section 12, referred to above, was opened in 1895; the initial well being reported to have averaged 250 barrels of oil per day during the first month. Its decrease, however, was rapid, and the well was abandoned in 1902. Many other holes were drilled in that part of the township with the hope of extending the pool. One well in this vicinity yielded some gas from the Clinton limestone. Practically no drilling was done in this township in 1902.

Freedom Township.—The southeastern portion of this is oil producing; the territory includes the whole or the part of sections 8, 9, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 32, 33, 34, 35 and 36. Besides this there is a very small area in the extreme northeast corner of the township. All territory in this township is simply an extension from that of Sandusky county.

Montgomery Township.—This township contains the largest area of producing territory in Wood county, all but one of its 36 sections yielding some oil. The territory, however, is quite spotted, a number of barren areas being enclosed by producing territory. Eastward the pool extends into Sandusky county, and westward into Portage township where it is connected by a narrow arm with the territory lying in the western portion of the county now under consideration.

Few wells were to be found in the township in 1890, but active work began about that time. Little testing was being done in 1902, and it seems that not much can be expected from the township in the future. The gravity of the oil is 42 degrees B., about two degrees lighter than most oil secured in Wood and adjacent counties.

Perry Township.—This township contains small areas of oil territory in two opposite corners, the northeast and the southwest. The former includes parts of sections 1, 2, 3, 4 and 12, and extends into Montgomery township on the north and into Sandusky county on the east. The second area referred to above extends as a narrow strip diagonally across section 32, and includes in addition a few acres in 29, 30, 31 and 33. A few small wells have been secured in section 34 also, but none were being operated in July, 1902.

Wells Drilled.—The wells drilled in the county from 1891 to 1899 have been as follows:

	Producers.	Dry.	Totals.
1891	530	92	622
1892	655	77	732
1893	663	97	760
1894	746	139	885
1895	347	40	387
1896	1,411	181	1,592
1897	677	114	791
1898	746	91	837
1899	976	79	1,055
Totals	6,751	910	7,661

This shows that 88 per cent. of the wells were producers and 12 per cent. failures.

GEOLOGY OF THE COUNTY.

The surface of Wood county is either flat or gently rolling. It comprises part of the territory formerly known as the black swamp, a large tract now constituting one of the richest parts of the state, whether considered from an agricultural standpoint or from that of underground wealth. The surface rocks are the Lower Helderberg over the greater portion of the county, but near the central part and along the southern and southeastern borders the Niagara is found. The succession of strata below the surface is shown by the following record of a well at Bowling Green.[1]

	Feet.
Drift	8
Niagara limestone	162
Thin break (shales)	
Blue limestone	5
Niagara and Clinton limestone and shales	108
Medina shales (red)	47
Cincinnati (Hudson River) shales, blue with thin sheets of limestone	462
Utica shales (brown)	300
Trenton limestone at	1,092
Bottom of well at	1,648

The sharp fold in the Trenton limestone found in this county has already been reported by Dr. Orton. It is conspicuous as far north at least as Bowling Green, but in the northern part of the county flattens, not being conspicuous thereafter. The size of this fold is well illustrated by the following data:

Plain township, section 36, southwest quarter; Trenton at 1,090 feet; 400 feet west of this the same formation was struck at 1,306 feet, a drop of 216 feet. On the east line of this section the Trenton was found at 1090

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 112.

feet, showing that for one-half mile at least east of the fold the rock is horizontal.

On section 26 lying northwest of the last section, the Trenton was found on the east side of the Case farm at 1132 feet, and on the west side of the same farm, one-half mile distant, at 1372 feet, a drop of 240.

On section 23, which lies due north of 29, the Trenton was struck on the P. J. Brown farm at 1153 feet, and 400 feet west of this, on the Isaac Brown place, at 1320 feet, a drop of 167 feet. It is stated by a person well informed on the subject that the strip of producing territory extending from sections 22 and 23 north past Haskins lies on this fold, but that the latter is not as marked there as farther south. By reference to the map it will be seen from what has been said that the fold lies one mile west of Bowling Green and not directly beneath it as has been stated.

The following data show the position of the Trenton in Wood county. The first records are from the southern part of the county, along the B. & O. R. R., which in fact was used as a datum line.

Township.	Section.	Drive Pipe.	Casing.	Depth of Trenton in feet.	Feet below sea level.
Perry	32	36 ft.	370 ft.	1154	390
Bloom....	36			1120	360
Bloom....	33	30 "	235 "	1068	321
Bloom....	31	30 "	270 "	1100	364
Henry....	34	28 "	370 "	1171	431
Jackson..	31	70 "	600 "	1461	740

This shows that the summit of the fold lies on or near section 33 of Bloom township, from which it dips to the east 70 feet in five miles; and westward 110 feet in the same distance, but continuing west the dip increases, so that it amounts to 309 feet in 9 miles.

Six miles north of the preceding line the Trenton is found at the following depths:

Township.	Section.	Depth of Trenton in feet.	Feet below sea level.
Perry	1	1200	493
Bloom.....	6	1023	322
Henry.....	1	1153	450 (approx.)
Henry.....	3	1167	467 "

This shows that Cygnet is on or very close to the sharp fold to which reference has already been made. East from Cygnet the dip is fourteen feet per mile.

Three miles farther north the following data were secured:

Township.	Section.	Trenton.	Below sea level, (approximate feet.)
Montgomery	15	1200	500
Portage.....	18	1135	445
Liberty.....	24	1260	560
Liberty.....	20	1250	550
Liberty.....	19	1300	600

From what has been said it is apparent that in Wood county the Trenton limestone makes considerable change in position. The most prominent is the sharp fold running north and south, west of the middle of the county. In fact this is one of the most abrupt folds known in Ohio. Westward from this disturbance the rock dips to the west 22 feet per mile for perhaps five miles, and then increases to 35 feet. On the east side of this fold the rock lies apparently flat, but careful measurement shows that it dips to the east. In the northern part of the county the rock dips to the north. The Trenton lies highest in Bloom township on the south side of the county.

It was formerly thought that when the Trenton had been penetrated 50 feet without securing the desired fuel, hope must be abandoned. Indeed by far the larger part of oil secured has been derived from depths less than that just given. However good producers have been found farther down. One of the first wells to help break down the early view was the Ducat, drilled in Liberty township, Wood county, about 1887. The story of this well reads like a romance. A poor German had secured a twenty acre lease in what was regarded "wild-cat" territory. He had a very poor string of tools, putting in these and the lease every dollar that he could command. When he reached the Trenton rock it yielded no oil, and the driller became greatly discouraged. However, he had staked all—and consequently was compelled to drill deeper, hoping for the best. At 50 feet a strong flow of gas was found, but no oil. The outlook now was practically hopeless, in view of the results in other fields. At this stage a representative of the Standard Oil Company, who has furnished these data, chanced to be driving by. Hitching his horse he walked to the derrick, and found the facts as just related. The driller was still at work, but with so little hope that he offered to sell the lease and well at cost,

about $2,500. Not caring to add to the discouragement by refusing, the visitor promised to consider the proposition and drove away. A few minutes later, when only a fraction of a mile from the well, he heard a loud report, and looking back saw a solid stream of oil flowing from the well, and rising higher than the derrick. He at once returned to the well, offering to purchase it on the terms which the driller had proposed a half hour before, but now it was the latter's opportunity to decline.

The giant was not gotten under control for 48 hours, and during all that time flowed over the derrick top. By actual guaging it later produced at the rate of 10,000 barrels per day. When it was flowing over the derrick the production was probably several times larger.

The owner kept the well about six months and then sold it for $10,000. The well changed hands several times, finally becoming the property of the Standard Oil Company. Another hole was drilled on the same lease, but it is reported to have never exceeded 15 barrels per day. The driller leased other tracts and made an immense fortune. He then bought a good farm on which he has since resided.

As has already been stated most of the oil from northwestern Ohio has been obtained from depths of less than 50 feet in the Trenton rock. Nearly always the top of the rock, called the cap, is free from both oil and gas. Immediately below this, these fuels may be expected. Sometimes they are found at about the same depth in the rock over considerable areas, but at other times the depths change rapidly. An illustration of this is found in Bloom township, where a driller of wide experience reports no definite horizon in the rock at which oil or gas may be expected. Within a distance of a few rods this may vary 50 feet.

One of the comparatively recent developments in the Trenton rock is the deeper pays. Sometimes two are found and at others three. The positions of these are made clear by the following data:

Township.	Section.	Top of Trenton. Feet.	First Pay. Feet.	Second Pay. Feet.
Bloom .	31	1100	1142	1250
Bloom .	33	1068	1108	1268
Bloom .	26	1103 (gas) (oil)	1174 1222	1238 (gas) 1278 (oil)
Bloom .	23	1099 (oil) (gas)	1176 1212	1265 (oil) 1310 (oil&gas)
Henry .	34	1171	1195	1235

Near Bairdstown, while the first pay had the largest initial production, the second one promises to have the longer life. The upper and lower pools are by no means coextensive. The lower one has not been

reported north of Bloom, Henry and Liberty townships. The third pay was not discovered until about 1900. In parts of Wood county many wells are being drilled deeper with the hope of striking the second or third pay.

Another characteristic of the Trenton in the vicinity of Welker and Bairdstown is the presence of numerous crevices. These are reported in nearly every oil field, but are usually looked upon with much suspicion by geologists. In this field, however, the crevices are so persistently reported by drillers and operators that there seems no reasonable doubt of their existence. Further, fragments blown up by torpedoes sometimes show a honey-comb structure, the openings having a length of several inches. The surface of these cavities indicate that the work has been done by solution. The larger crevices have probably been made in the same manner by enlarging cracks and joints. The depth of crevices vary greatly, usually ranging from a few inches to a foot or two, but occasionally much larger depths are reported. As will readily be understood these openings are much dreaded by drillers; when the crevice is not vertical the hole is in danger of becoming crooked, and the tools are liable to become fast.

It appears that many of the largest oil and gas wells were secured in localities where crevices are numerous. Such wells commonly begin with a very heavy flow, and this may be long maintained. There are many cases, however, where such wells have been exhausted in a few months, the theory being that the crevice has been emptied. Sometimes when extra large producers have been secured, a rival company, owning an adjacent lease, drills on it with the hope of securing part of the oil or gas. If this is not secured when the Trenton rock has been penetrated to a depth of perhaps 50 feet, a heavy charge of nitroglycerine is used to break into the crevice. It is believed that efforts of this kind have been failures more frequently than successes.

Occasionally oil and gas are found in rocks other than the Trenton. On section 51, "Maumee river tract," a well drilled in the autumn of 1901 found oil in the Clinton limestone, the production being 3 barrels per day in the following July. In fact it is not uncommon to find a small quantity of oil and gas in this formation.

The great shales lying below the Clinton also produce occasionally both oil and gas, but as a rule the duration of such is brief. A well in Bloom township had an initial production of 300 barrels per day, the oil having been secured at a depth of 300 feet in the Cincinnati shales. This produced between 4,000 and 5,000 barrels of oil, and then giving out, the hole was extended to the Trenton. A well near Waterville found oil at the same horizon, the production starting at 125 barrels per day. The total yield, however, did not exceed more than 2,000 barrels.

Barren Tracts Enclosed by Producing Territory.—This is one of the characteristics of the county. As may be seen from the map these vary in size, position, and direction of extent. Wells drilled in them frequently yield some oil, but rarely in paying quantities. The cause for their existence is not understood. The rock lies at about the same elevation as that of the surrounding producing territory, thus apparently precluding the idea that the barrenness results from the position of the rock. However in some cases the rock lies a little lower, so that it is possible that position may be in part at least the cause of the absence of oil. The fact that such tracts sometimes contain large quantities of salt-water lends weight to this idea. To the writer it seems more probable that the absence of oil results from changes in the texture of the rock, by which it becomes too compact to serve as a reservoir. Possibly this may follow from a change in the rock's composition, the carbonate of magnesia having decreased and that of calcium correspondingly increased. However tests have not been made to prove or disprove this suggestion. It is not an easy matter at this late day to procure samples of Trenton from this territory.

Size and Duration of Wells.—This county may be considered the richest part of the Trenton limestone field. In making this statement, extent of territory, size of wells, and period of production is considered. Probably the largest well in the county was the Ducat, whose history has already been given. There were several wells having an initial production of 5,000 or more barrels of oil during the first 24 hours. One located a mile north of Hammonsburg in Henry township, is reported to have produced 15,000 barrels of oil per month during a year. One of the most recent of the large wells was drilled in 1893, and was located on the P. J. Brown farm, section 22, Plain township. After having flowed openly during 15 hours, the well was gotten under control, and then filled a 250 barrel tank in 52 minutes—a rate exceeding 6,000 barrels per day.

The production of the county, however, was not derived from these large wells, but from those having an initial production ranging from perhaps 25 to 500 barrels. Wells drilled in recent years have been relatively small; those completed in 1901 rarely exceeded 40 barrels, while those drilled later were still smaller. In the summer of 1902 the wells in the western half of the county averaged about 3 barrels each per day, but those on the eastern half were smaller, averaging less than two barrels each.

The average life of wells—a question frequently asked—is difficult to state. The territory, however, is long lived, as much so as any in northwestern Ohio; and wells having had a heavy initial production (say 500 barrels per day) are said to produce on the average from ten to twelve years. Gaugers report the average decrease in the production of a well to be about 12½ per cent. each year. The number of new wells being

drilled in this county in 1902 was at the rate of two for each one abandoned. It is reasonable to expect that the ratio of the latter group with reference to the former one will be largely increased during the next few years.

Salt-Water.—No county in the entire Trenton limestone field has been underlain with a greater reservoir of salt-water than Wood. This was a serious obstacle in the days of natural gas, causing the premature death of more than one well. At first the water was regarded as a formidable obstacle to oil development, but it was soon found that the two could readily be separated, and that the principal increase in the cost of production was that arising from pumping the salt-water. Later it was found that after having been pumped regularly the reservoir of water decreased. It was further noted that these wells were very long producers of oil, and consequently they have come into favor. Many wells when completed, have not made a show of oil, but after having been pumped for weeks or months began producing oil. One has been reported as having been pumped 27 months before oil appeared, and later yielded 400 barrels per day. Many claim that the salt-water prevents the wells from paraffining.

The quantity of water pumped from the Trenton in this county has been enormous. During 15 years thousands of pumps have been at work, many stopping for repairs only. As might be suspected the reservoir has been greatly reduced, and at the present time causes much less trouble.

HANCOCK COUNTY.

The Wood county oil fields are connected with those of Hancock by two independent branches. One of these lies on the west side of the county, the other on the east.

The western branch enters the county through Allen and Portage townships and includes a large part of Liberty to the south, having a width there exceeding five miles. The area of this pool is about 43 square miles.

The eastern branch passes from Bloom township, Wood county, into Cass of Hancock, and extends entirely across this township and then enters Marion on the south. From this it extends into Big Lick, and finally into the northern part of Amanda. While this strip is long it is so narrow that the total area probably does not exceed 9 square miles.

Besides these two pools there are several smaller ones found in different parts of the country. The positions and areas of these are made clear from the following descriptions:

Allen Township.—The producing territory extends south from Henry township, Wood county, into Allen of Hancock, entering section 2, and running nearly due south as a narrow strip about three-fourths of a mile in width, to near the south line of section 11. At this point the western boundary of this strip bends due west entering section 10 of Portage.

Continuing south in Allen township the producing territory covers a tract one and three-quarters miles in width including in whole or in part sections 13, 14, 23, 24, 25, 26, 35 and 36. Near the village Mortimer a very narrow belt leaves the main area, extending nearly due east about one-half mile, then making a right angle, and running due north one and one-half miles. This lies principally in sections 18 and 19. Gas wells are found in sections 6, 7, 12, 17, 18, 19, 30 and 31.

In the extreme northeast corner of this township a few acres of oil territory are found. This extends south from Bloom township, Wood county, and west from Cass of Hancock.

This was part of the earliest territory to be developed in this county. After the completion of the pioneer wells at Findlay work was extended northward, fine producers of gas having been secured in many cases. With the active beginning of the oil industry in 1886 work began in earnest in this township, and drilling has been in progress with little interruption since that time. The limits of the producing territory have long been demonstrated, and the later work has been within these.

Portage Township.—The producing territory of Henry township, Wood county, extending south enters section 4 of Portage township, Hancock county. It is there over one-half mile in width. From this point the area runs southeast through sections 4 and 10; near the line of junction of these, the strip is very narrow, being represented in fact by a few scattering wells only. From section 10 the eastern margin of the territory under consideration extends east into Allen township. The western margin of the pool extends south through sections 10, 15, 22, 27, 28 and 33, and then west through 33, 32 and 31.

This township lies west of Allen, and its development went hand in hand with that. Probably by 1890 the limits of the producing territory had been demonstrated. The greater part of the drilling has long been done, and the life of the field will be determined by that of the wells already drilled.

Liberty Township.—The territory in Portage and Allen townships extends south into Liberty township, and also into the corporation of Findlay. In the latter the margin of the pool runs nearly south to Sandusky street where it turns west passing from the city limits. Outside of Findlay the pool includes the whole or part of sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 20, 21, 22, 23, 27, 28, 29, 32 and 33.

This has the largest area of producing territory of any township in the county. Active drilling for oil began in the spring of 1886, making the real beginning of the industry in the county. Wells have been drilled from time to time since that date. At first they were put down rapidly and in great numbers, but in a few years the best territory was drilled, and since that time work has been much quieter. From this township the pioneer drilling extended north into Allen and Portage.

Eagle Township.—About one mile southwest of the large pool in Liberty township there is a small pool in Eagle township. It has an area of perhaps two and one-half square miles, and includes parts of sections 5, 6, 7, 8, 17, 18 and 19. From this it runs west into Union township. Farther south along the township line a small pool is found in the northwest quarter of section 31.

Development in this township lagged behind that in the townships previously considered. Work is reported to have begun about 1891, and the small areas of production were soon outlined. However, the drill was still at work in 1902, and with fair success.

Union Township.—The oil territory in this township is restricted to the southeastern quarter. The main pool in Eagle township extends just over the line into Union, but the small pool in the southwest corner of Eagle expands after having entered Union, and includes parts of sections 23, 24, 25, 26, 35 and 36. From section 35 the pool extends south into Orange township. In the northeast quarter of section 27 a few wells are found.

The discovery and development of the productive territory in this county may be correlated with that in Eagle. Some wells were still being drilled in 1902, and it is probable that work will be continued on a small scale for several years.

Orange Township.—The pool in Union township to which reference has just been made extends into the north half of section 2, and then disappears.

The western half of this township contains an extension of the Allen county pool, including section 8, and parts of 4, 5, 6, 7, 9, 10, 15, 16, 17, 18, 19, 20, 21 and 29. Section 30 also contains a few wells, another extension from Allen county.

Cass Township.—The great pool in Bloom township, Wood county, extends south into Cass township of Hancock, entering in the extreme northwest corner, and extending south entirely across the township. It forms a narrow strip ranging in width from less than one-half mile to more than a mile, and includes parts of the following sections,—4, 9, 10, 14, 15, 16, 22, 23, 26, 27, 34 and 35. The township produces some gas from sections 4, 14, 15, 22 and 23.

Development began at an early day, probably in 1886, and work has been in progress since that time. However, the production has never been large, and not much can be expected in the future.

Marion Township.—The territory referred to above extends south entering Marion township in sections 2 and 3. From section 2 a branch runs due east entering Big Lick township, but the main strip runs slightly east of south, passing through sections 11, 12, 13, 14, 23, 24, 25 and the northeast corner of 36, and then bending east enters Big Lick. The

width of the territory in Marion township ranges from one-eighth mile to one mile or more. The township still yields considerable natural gas. The wells lie in sections 1, 2, 3, 6, 8, 11, 12, 14, 15, 16, 17, 21, 22 and 23.

As late at least as 1890 extensive gas territory existed in this township, but the rock pressure had become relatively small, and many wells began flowing oil. By 1892 the yield of oil had become large, and from that time the township may be classed as a producer of oil rather than of gas. Ten years later considerable drilling was still being done.

Big Lick Township.—The oil fields of Marion enter this township in the northwest and southwest corners. That in the northwest corner passes through sections 6, 7, 8 and 17.

That in the southwest corner enters sections 30 and 39 and taking a southeasterly course enters Amanda township. The producing territory in this township is very small. Its area is about one square mile. The development is reported to have begun in 1897.

Amanda Township.—The territory entering this township from Marion forms a very narrow strip, and does not reach the middle of the section. It comprises about 20 acres, and was drilled principally in 1900.

Jackson Township.—The principal production of this township is natural gas, the greater number of the wells being found in sections 15, 16, 21, 22, 27 and 28, but gas wells are found in sections 5, 6, 7, 8, 9 and 26 also. In the extreme southeast corner of the township a few small oil wells are found.

Delaware Township.—The small pool of oil just mentioned extends over the line into Delaware township where it comprises about 80 acres, located in section 2.

Wells Drilled.—The well record in Hancock county for 1891 to 1899 was as follows:

Year.	Producing.	Dry.	Total.
1891	115	25	140
1892	78	13	91
1893	76	4	80
1894	276	64	340
1895	409	84	493
1896	576	103	679
1897	359	73	432
1898	263	38	301
1899	439	58	497
Totals	2,591	462	3,053

This shows 84 per cent. producers and 16 per cent. dry.

GEOLOGY OF THE COUNTY.

The surface rocks in the western and northern parts of the county are the Lower Helderberg limestone, and in the eastern part the Niagara. The succession of strata under ground is shown by the following record of a well at Findlay.[1]

	Feet.
Drift	8
Niagara limestone	162
Blue limestone	5
Niagara and Clinton limestone and shale	108
Medina shale, red	47
Cincinnati shales, blue with thin sheets of limestone	462
Utica shales, brown	300
Trenton limestone at	1,092
Bottom of well (in Trenton)	1,648

The position of the Trenton along an east-west line in the northern part of the county is shown by the following data:

Pleasant Township, near McComb: drive pipe, 62 feet; casing, 630 feet; Trenton at 1,412; elevation of well head, 730 feet above sea level.

Portage Township, northwest quarter of section 10: drive pipe, 34 feet; casing, 409 feet; Trenton at 1,201 feet; elevation of well head about 750 feet above sea level.

Allen Township, west of Van Buren: Trenton at 1,232 feet; elevation of well head, 780 feet above sea level.

Cass Township, southwest quarter of section 15: Trenton at 1,150 feet.

Washington Township, near Arcadia: Trenton at approximately 1,200 feet; elevation of well head, 806 feet above sea level.

These records indicate a gradual slope from the center of Cass township to the east and west. Just north of Van Buren, Allen township, the Trenton is found at 305 feet below sea level, this being probably its highest altitude in the northern part of Hancock county. Examination of the tier of townships lying south of that just given shows similar conditions. Wells drilled outside of the main pools show the same general succession of strata and depths as those previously given. In fact, the Trenton limestone in the producing portions of Hancock county lies nearly flat, the altitude varying but little from place to place. To this there is one noteworthy exception—the Findlay arch. This has already been fully described by Dr. Orton in Volume VI, and the First Annual Report (1890) and those who desire a detailed account must refer to those volumes.[2] Suffice it to state here that at Findlay a sharp bending of the strata is found, the result being that the Trenton drops to the west 150

[1] *Geol. Sur. of Ohio,* Vol. VI, p. 112.

[2] *Ibid,* pp. 120, 133-5 and First Ann. Rep. 1890, Plate II.

feet in less than one-half mile. It was at the margin of the higher side of this flexture that the great Karg well was drilled. East from Findlay the rock lies nearly horizontal, as has already been stated. Its depth, however, increases slowly on both the east and west sides of this arch.

Another interesting disturbance is found in section 22 of Cass township. This is a peculiar folding of the Trenton rock, called by drillers "the hog back." On the Hiram B. McCracken farm, in the northeast quarter of the section, the Trenton is found at 1,040 feet; on the A. M. Greenlee farm, a well 400 feet east of the last one found the Trenton at 1,167 feet, a drop of 127 feet; one-quarter of a mile west of the McCracken well the Trenton was found at 1,107 feet, a drop of 67 feet; and one-fourth of a mile south it was found at 1,115 feet, a drop of 75. Drillers report the formations in the "hog back" liable to cave, while the Trenton is said to contain many fissures. Salt-water is abundant.

The oil rock east of Findlay sometimes contains numerous holes, resembling in some respects a sponge, and drillers frequently report crevices in the formation, as is shown by the tools dropping suddenly from a few inches to several feet. West of Findlay the cavities in the Trenton are less common, but the oil is not confined to the surface portions of the formation. In fact, several "pays" are sometimes found, but these do not form well-marked bands or zones. In the southwestern townships the lower pays had not been worked prior to 1899; since that time many old wells have been drilled deeper, and in this manner changed from the nearly exhausted to good producers. The oil secured from the lower pays has thus far been insignificant in value in comparison with that received from the higher or first pay. The latter is commonly formed at a depth not exceeding 50 feet.

Production of Wells.—It is difficult at this late date to give accurate data concerning the initial production of individual wells. Doubtless, however, there were many which yielded hundreds of barrels per day, and perhaps occasionally one that flowed 1,000 barrels or more. At the present time, however, the wells are small. The territory in the eastern part of the county, having been developed more recently than that farther west, has the largest producers. On section 15 of Cass township the average production per well is about 5 barrels per day; on section 22 it is not less than 25 barrels. In Marion township the average production is smaller, having been reported at 20 barrels. The wells are kept pumping day and night to control the large volume of salt-water which threatens their life. The ratio of salt-water to oil pumped in 1902 was about five to one.

Amanda township makes a similar report for its small territory. On section 6 the wells averaged each about 15 barrels per day in the summer of 1902. In July, 1901, two wells completed on this section had an initial production of 8 barrels daily, but after having been shot the production

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increased to 150 barrels per day for 20 days. By June, 1902, the production had diminished to 6 barrels per day.

West of Findlay the largest wells pump from 35 to 45 barrels per 24 hours, but those exceeding 15 barrels are rare, and many yield from two to three only. This territory was one of the first to have been developed, and this fact accounts for the present small production. It is interesting to note that some of the wells drilled 16 years ago (1886) are still producing.

In Eagle and Union townships the production averages less than five barrels per well each day, while in Orange township the yield is only about one-third of that. These wells produced from 50 to 60 barrels per day in 1896.

SANDUSKY COUNTY.

It was very natural that this county, lying as it does, just east of Wood and northeast of Hancock should be stimulated by the great discoveries made to the west and south. Fremont led the way, reaching the Trenton rock July 8, 1885, at a depth of 1,328, or 720 feet below tide. Considerable gas was liberated at several horizons, especially the Clinton, but there was little or no addition to the flow when the Trenton was reached, even after the latter had been torpedoed. However, the test demonstrated the existence of fuel, and that insured further exploration. By 1888 nine wells had been drilled in the vicinity, the results being similar to those disclosed by the first well. Small as the yield was, the company determined to make the most of it; accordingly a line was laid to the city, and a few citizens were soon enjoying the luxury of natural gas. The supply, however, was short lived. Finding gas in the Clinton formation and little or none in the Trenton, a number of shallow wells were drilled, the hope being that if the gas obtained from the Clinton should be small, it might be profitable, since the cost of drilling would also be light. However, the experiment was not a success, and the Northwestern Natural Gas Company was soon supplying the town from the great Wood county fields. Notwithstanding these repeated failures a well was drilled on the river bank near the State street bridge in 1901. The result was less encouraging than the tests made 15 years earlier, not a showing of either oil or gas having been found.

Later, tests were made to the west with better success, though not without disappointments. The records of these will be given later when the territory is taken up by townships. By inspection of the map it will be seen that the principal territory lies in the western tier of townships. A barren strip extending lengthwise through this territory is a feature.

Woodville Township.—A large part of this township produces oil, the sections being 8, 17, 18, 19, 20, 21, 22, 27, 28, 29, 30, 31, 32, 33, 34 and 35.

The first test was made at Woodville in 1886, the object being natural gas for use in burning lime. The Trenton was found at a depth of 1,184,

or 586 feet below tide level, being entirely free from the desired fuel and from oil also. So conclusive did the results seem that the well was not shot, which, as later developments proved, was a great mistake.

About two years later the search was renewed; this time with better results, though not so far as natural gas was concerned. Oil was found in paying quantities, and of course the drill was kept at work, the result being that what had at first been condemned as worthless territory proved to be rich in oil. Not only was the rock quite free from barren streaks, but several large wells were secured.

Madison Township.—This township, lying south of Woodville, has oil wells in every section excepting 15, 28 and 35, but in several others the areas are very small. The barren strip to which reference has already been made extends entirely across the township from north to south.

In 1887 a well was drilled at Gibsonburg for natural gas. The Trenton was struck at 1,237 feet, but flowed oil, the rate reported having been 50 barrels per day. This is said to have been the first oil well drilled in Sandusky county. Encouraged by this result another well was begun, the location being 2,000 feet west of the first one. This flowed gas, the rock pressure having been about 300 pounds per square inch. Other wells were completed with similar results, and the town was soon supplied with fuel. The flow of gas has been continuous, but is no longer adequate to meet demands (1902). The first well drilled in this locality exclusively for oil was in 1888. After having been shot with 80 quarts of nitro-glycerine, it began producing at the rate of 200 barrels per day. Progress has been uninterrupted since that early day, and consequently the territory is now well drilled.

Scott Township.—The oil territory of Madison township extends south into Scott, where all sections are productive, in whole or in part, except 2, 11, 12, 13, 14 and 24. From this township the production extends west into Wood and south into Seneca counties.

Development was contemporaneous with the township north, real progress beginning about 1890. Since that time the tools have been kept at work, the result being that little remains to be done.

Washington Township.—The territory in Woodville and Madison townships extends east into Washington, occupying in whole or in part sections 5, 6, 7, 8, 9, 16, 17, 18, 19, 20, 21, 29, 30, 31, 32 and 33. Outside of this three smaller pools are found; one lies at the junction of sections 23, 24, 25 and 26, the wells being about equally divided in production between gas and oil. About one-half mile north of this pool a gas well has been secured; the original rock pressure exceeded 400 pounds, the gas being used in carbon works at Fremont. In the southern part of the township a small pool of oil has been found occupying a fractional part of sections 34 and 35; it extends across the line into sections 2 and 3 of Jackson

township. Another small pool is found just southeast of Lindsey, in sections 11, 12 and 13.

Rice Township.—The little pool to which reference is made in the preceding paragraph extends eastward into sections 5, 6, 7, 8 and 18 of Rice township. This is sometimes called the Kingsway pool from the station of that name. Drilling began here about 1896 and has been continued since. As a rule the wells are small, and this has made development slow. The largest production reported was 70 barrels per day, and the normal about one-tenth of that. In July, 1902, the wells averaged about one and one-half barrels each per day.

Jackson Township.—A narrow strip of producing territory is found along the western border of this township. It includes in whole or in part sections 5, 6, 7, 8, 17, 18, 19, 20, 30, 31 and 32. Besides, there is a small area in sections 2 and 3, as has already been mentioned in the discussion of the preceding township. A number of gas wells are found in sections 31 and 32; these supply in part the villages of Burgoon and Kansas.

Wells Drilled.—The following figures show how extensively wells were sunk in the county from 1891 to 1899:

Year.	Producing.	Dry.	Total.
1891	198	35	233
1892	285	34	319
1893	389	39	428
1894	496	47	543
1895	924	70	994
1896	810	41	851
1897	239	19	258
1898	260	9	269
1899	431	21	452
Totals	4,032	315	4,347

GEOLOGY OF THE COUNTY.

The surface formation in the western part of the county, including the principal oil producing territory, is the Niagara limestone. Farther east the Lower Helderberg limestone extends across the county as a broad belt from north to south. This in turn is succeeded by a strip of Niagara, and this again by the Lower Helderberg; so that there are in all four separate belts of Niagara and Lower Helderberg limestones.

The underground succession is shown by the following record of a well at Fremont:[1]

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 112.

	Feet.
Lower Helderberg limestone	160
Niagara limestone	200
Niagara shale, and Clinton limestone	105
Medina shale	105
Cincinnati (Hudson River) shale	450
Utica shale	308
Trenton limestone at	1,328

Next is given a record of a well near Rollersville, in the southern part of Madison township; the well head is 689 feet above tide level:

		Feet.
Drive pipe		30
Niagara Series	Gray limestone	140
	White limestone	160
	Blue limestone	20
	White slate (first break)	2
	Brown limestone (hard)	21
	Light slate (second break)	20
Clinton limestone		100
Medina shales, red, soft		80
Cincinnati (Hudson River) shales		427
Utica shales, brown		252½
Trenton limestone at		1,252½

From this it is seen that the Trenton rock lies about 563 feet below tide level; it dips very gently to the north, being found 586 feet below at Woodville seven miles distant; near Lindsay, in the northern part of Washington township, it is 650 feet, and at Fremont 720 feet. In other words, the Trenton rock lies highest in the southwestern corner of the township, sloping very gently to the north, and in the same manner to the east. In the latter direction, however, the rate soon changes, and as a result the depth of the Trenton is found to increase rapidly, as is shown by the Fremont well.

The Oil-rock.—This is in all cases the Trenton limestone. Its character agrees in every respect with that found in Wood and other counties. Formerly it was customary to drill a few feet only into the oil-rock; later, depths from 50 to 100 feet were reached, and this custom now prevails, especially with the largest producer in the field—The Ohio Oil Company. The greater depth has the advantage of penetrating a possible deeper pay, and also acting as a cistern into which the sediments may accumulate. All wells are torpedoed, the size of the charge ranging ordinarily from 50 to 200 quarts. The pay commonly ranges in thickness from 5 to 30 feet; it is more porous and commonly has a darker color than the enclosing rocks, and hence is easily recognized.

Barren Area.—As has already been stated there is one conspicuous barren area; this has a length of ten miles and a width usually of from

two to three. Occasionally a small group of wells is found in this area, but their production is small and life short. Mr. F. W. Zorn, of Gibsonburg, who has had much experience in the territory under consideration, states that a small syncline runs through the barren tract northwest and southeast, that is, parallel to the longer axis. He reports also the rock hard and fine. It appears to the writer that the barrenness of the rock is due more to the latter qualities than to the syncline, since the depression is very inconspicuous. The existence of small wells lends support to this theory.

Size and Duration of the Wells.—By far the greater number of wells have been of ordinary size, that is the initial production has ranged from 25 to 100 barrels per day. There have been a few notable exceptions to this, one of which is famous in the history of the oil fields in northwestern Ohio.

The first of the large wells was not drilled until August, 1892. It was located on the Baker farm in section 29, Woodville township, and had an initial production of 200 barrels of oil per hour, and 2,500 per day.[1] Some have placed the production considerably higher.

The great well to which reference has already been made is known as the Kirkbride. It stands on the H. Jones farm in the southeast corner of section 19, Madison township, and was completed November 17, 1894. A short time before, a well was drilled on the Myers farm adjoining, and after having been shot is reported to have produced 2,000 barrels of oil the first day. Good wells were secured north of this one, so that the territory was in good repute before the Kirkbride was drilled.

Work progressed in normal fashion for the district. When the Trenton had been penetrated to a depth of about ten feet a great pool of oil was liberated. The oil was thrown as a solid stream to the top of the derrick where it was broken by the crown pulley, and the spray caught by a strong south wind was carried a mile north. A half-mile from the well, farmers were obliged to disconnect the spouting on their houses to prevent the oil from running into the cisterns.

The oil began flowing about 9 in the morning; and the drillers, not expecting a heavy production, were totally unprepared. Not until the middle of the afternoon was the giant gotten under control, and during all this time the oil was thrown over the derrick and then fell on the ground below. Part of this, however, was saved by damming a stream into which the oil flowed. When under control the well was never allowed to flow freely, and so its maximum production was never determined. This, however, has been estimated all the way from 10,000 to 40,000 barrels the first day. While wells of comparatively small size are usually greatly overestimated, the writer believes that those of the Kirkbride type are commonly underestimated. In January, 1901, the well was pumping four

[1] *The Derrick Hand Book of Petroleum*, Vol. I, p. 550.

barrels per day. It was still producing in August, 1902. The fact that just across the road from the Kirkbride very small wells were secured has given rise to the belief that the great well was of the crevice type.

The life of the wells corresponds to that found in adjacent counties. Those in the so-called barren tract, as has already been stated, are soon abandoned; but those in better territory produce much longer. In fact, it is doubtful if the maximum life of a well in this county has yet been determined. The oil ranges from 38 to 39 deg. B. in gravity.

Salt-water.—This has been found in all parts of the county, but the quantity has been smaller than in Wood. Nowhere does the brine seem to have been a serious obstacle. Sometimes a small quantity has been found in the Clinton, but here as elsewhere the great volume has come from the Trenton.

SENECA COUNTY.

Lying east of Hancock county, and containing the two progressive cities Tiffin and Fostoria, it was very natural that the underlying rocks of Seneca county should be tested early. The results of these explorations have already been outlined: Fostoria never secured the desired gas, though she later obtained a supply from Wood county; and oil too was denied her. Tiffin was a little more fortunate, securing a small quantity of both products.

Developments during the past fifteen or sixteen years have done very little for the county, though the rocks have been extensively tested. The only productive territory is found in the northwestern corner, and around Tiffin.

Hopewell and Clinton Townships.—This includes the Tiffin pool, having a length of four miles and a width not exceeding one and one-half miles. By far the greater portion of the territory lies in Clinton township, a strip a few hundred yards wide only extending into Hopewell.

The first well was completed in January, 1886, and made a showing of oil, gas and salt-water. After having been shot with rack-rock it was put to pumping, and yielded a small quantity of oil for several years. Well No. 2 drilled the same year, was located about one mile west of No. 1, and found the Trenton rock 120 feet lower than the latter well. After having been shot this well flowed from 8 to 15 barrels of oil per day; it continued flowing until 1900 when it was put to pumping; in July, 1902, it was still numbered among the producers. These results gave rise to much excitement, and led to extensive leasing of land in the vicinity of Tiffin. Several additional wells were drilled in 1887, but the results did not meet early expectations, and matters became quiet until 1892.

During that year a large number—perhaps two score of wells were drilled along the banks of the Sandusky river, many of them in the heart

of the city. The wells are said to have all been producers, the initial production ranging from 30 to 120 barrels per day.

In 1895 the Beatty Glass Company drilled a well for gas on the Maul farm along the corporation limits. The well was shot, and then, instead of yielding natural gas, flowed 100 barrels of oil per day. The well is reported to have been sold for $8,000.

The next and last boom started in 1900. In that year a well was drilled on the Van Natta farm, by the side of a gas well drilled eight years before. The new well made the largest demonstration of any drilled in the vicinity of Tiffin. It flowed two or three times per day, and each flow is reported to have produced from 300 to 400 barrels. Once more Tiffin had the attention of the driller; work soon began in earnest, and before the boom was over about 50 wells had been drilled in the vicinity of the Van Natta. A goodly number of these were dry, but about 20 of the producers were still yielding oil in July, 1902. An effort was made to extend the territory to the southeast, and while oil was found in nearly every well, the quantity was not such as to warrant operation.

Since 1900 the territory has been quiet, only an occasional well having been drilled.

Jackson Township.—This contains a larger area of oil territory than any other township in the county, comprising sections 4, 5, 6, 7, 8 and parts of 1, 2, 6, 9, 10, 15, 16, 17 and 18. The territory is an extension of that in Sandusky county on the north and Hancock county on the west, and its development followed naturally that of the adjacent counties.

Liberty Township.—This contains no oil territory, but in the northwestern corner, near Kansas, there is a small reservoir of gas. The first well was drilled about 1895 and the flow has been continuous since that time. However, the village is connected with several wells just over the line in Sandusky county, and these have done half or more towards keeping up the supply. About 60 fires are supplied, the rate being $3.00 each in winter and $1.50 in summer. The gas is found at about 35 feet in the rock, and at a depth of about 50 feet work ceases.

Wells Drilled.—The wells drilled in this county from 1896 to 1899 have been as follows:

Year.	Producing.	Dry.	Total.
1896	228	10	238
1897	47	6	53
1898	66	1	67
1899	53	2	55
Totals	394	19	413

This shows that 95 per cent. of the wells drilled were producers.

GEOLOGY OF THE COUNTY.

The surface rocks in the western part of the county belong to the Niagara; those near the middle to the Lower Helderberg; and those farther east to the Corniferous limestone and the Ohio shales. By far the greater part of the producing territory has the Niagara for the surface formation. The topography resembles that of the adjacent counties on the west; it is flat on the west and northwest sides, rolling in the middle and eastern parts. A beach of ancient Lake Erie crosses the county from the southwest to the northeast, and is the most striking feature of the surface geology of the county.

The succession of strata underground corresponds very closely with that in the counties west and north, and consequently will not be repeated here. The Trenton limestone in the northwestern corner of the county is part of the nearly flat dome, that forms so striking a feature of the oil territory in that part of the state. Its position is about 475 feet below tide level. From this corner the rock dips east and south, at Tiffin being 765 feet, and at Attica, on the east side of the county, about 1,130 feet below sea level. At Tiffin a small fold is found; well No. 1 drilled near the north of Rock creek, found the Trenton at 1,490 feet, while No. 2 drilled about one mile to the west, did not reach that formation until a depth of 1,610 feet was reached. The latter well stands on higher ground, but not sufficient to account for the increased depth of the Trenton. The boundaries and direction of extent of the arch have not been determined, but the productive territory indicates that it is crescent shaped, with the convex side turned to the west. In other respects the geology of the county is similar to that of Sandusky and Hancock, and the facts that have been stated for those counties will not be restated here.

ALLEN COUNTY.

The oil territory in Hancock county extends southwest into Allen, where it makes it first appearance in Richland township. It continues southwest across the county as a series of disconnected but closely related pools, and then enters Auglaize county. In the western part of Allen two large pools are found, and one of these extends westward into Van Wert county. Besides these pools there are several small ones. These points will be made clear in the following discussion by townships:

Ottawa Township.-This is coextensive with the Lima city limits. The first well was drilled in 1885, and work became active one year later. By April 1, 1886, fourteen wells had been completed; by July 1, fifty-seven, and by November 1, one hundred and sixty-five. The production by months was as follows:

	Barrels.
September (1886)	4,500
October	7,000
November	8,300
December	9,500
January (1887)	8,500
February	11,700
March	10,400

Doubtless, however, many of these wells were outside of Ottawa township. By April 1, 1887, there were 283 wells completed in the Lima field.

So impressed was Dr. Orton with the possibilities of the territory that he wrote in 1888: "The field has risen in importance until, at the present time, it is unquestionably not only the most important oil field that Ohio has ever had, but by all odds the most important field, so far as the possibilities of production are concerned, yet found on the American continent."[1]

In 1902 the eastern part of Ottawa township was still producing oil, and not improbably good wells might be secured in the heart of Lima.

Richland Township.—The producing territory in Hancock county enters this township through sections 13 and 24, and continues southwest into 23 and 25, the maximum width being about one and one-half miles. In the western half of section 23 a small pool was opened in the summer of 1902, comprising at that time about 80 acres. In the southwest corner of this township a larger pool is found. This includes the territory around Beaver Dam, and hence is sometimes called the Beaver Dam pool. It includes parts of sections 27, 28, 29, 30, 31, 32, 33 and 34. A small outlier is found north of this pool. It seems very probable from work done in 1902 that all these pools will soon be connected.

Work in this township began late in 1885 or early in 1886, the test having been made at Beaver Dam. The Trenton was found at 1,309 feet and contained both oil and salt-water; but the former was small in quantity and the well was plugged and abandoned without having been shot. It remained in that condition until 1899, when new casing was inserted and the well put to pumping. At first it yielded 25 barrels per day, but this decreased rapidly and was very small in 1902. Encouraged by this experiment, other wells were drilled the same year. The first one was located within the corporation, and had a reported initial production of 100 barrels per day. Since that time work has been active, and, of course, the producing area extended. In 1902 fine wells were being secured in section 34, two and one-half miles east of Beaver Dam.

Jackson Township.—The Beaver Dam pool extends south into this township, entering the extreme northwest corner and including the whole or parts of sections 5, 6, 7, 16, 17, 18, 19, 20 and 30. The length exceeds

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 168.

four miles, and the maximum width approaches two and one-half miles. About one mile east of this pool a small outlier is found in sections 15 and 22. Near the village of Lafayette a number of wells have been drilled, but without favorable results. It seems quite probable in view of recent developments near the south line of Richland township that section 13 of Jackson may also soon be included in the producing belt.

Monroe Township.—This lies west of Richland, and has an extension of the Beaver Dam pool in the southeast corner. This includes parts of sections 25, 26, 35 and 36, though it comprises one square mile only. A number of wells have been drilled in other parts of the township, but without success. The sections on which tests have been made are 13, 16, 17, 18, 20, 21, 31 and 33. It is one of the parts of the county most recently developed. From tests made it does not seem probable that the township will become an important producer. However, if in the future smaller wells can be operated with more profit than at present, this territory may be more extensively drilled.

Bath Township.—In the extreme northeast corner of this township a small extension of the Beaver Dam pool is found. This comprises about one-quarter of a section. Near the center of the township a small pool, about one-half section in area, is found. It includes parts of sections 9, 10, 15 and 16. A large extension of the Lima pool is found in the southern half of the township. It includes sections 26, 27, 28, 29, 33, 34, 35 and parts of 19, 20, 21, 22, 23, 24, 25 and 36.

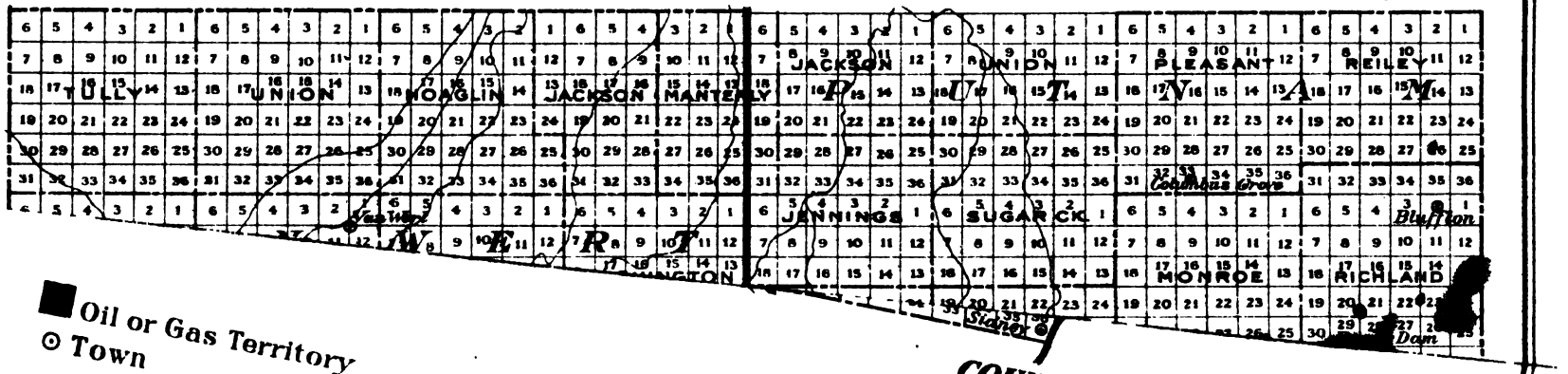
The development of this township began at an early day, perhaps late in 1885, and the drill has been kept at work ever since. Little progress has been made in late years, however, and no important extensions need be expected.

Perry Township.—The larger portion of the township is occupied by what has already been referred to as the Lima field. It includes sections 2, 3, 4, 7, 8, 9, 16, 17, 18, 19, 20, 21 and parts of sections 1, 10, 11, 12, 14, 15, 22, 23, 28, 29 and 30. This township contains a portion of the territory that was the first to be developed in northwestern Ohio. Work began in 1885 and drilling is still being done. Territory that was once discarded as worthless has been proven to be quite valuable.

Auglaize Township.—This occupies the southeastern corner of the county. The only producing territory is in section 6, where a small extension of the Lima field is found. However, tests have been made at several places, including the following sections,—5, 8, 10, 17, 18, 21 and 25.

Shawnee Township.—This includes part of the Lima pool, the sections being in whole or in part 13, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29 and 30. Besides this there are five small pools in the township; one of these containing two or three wells, lies in the middle of section 28, and another of similar size is found in the northeast quarter of section 6. In sections 5

MAP II.



■ Oil or Gas Territory

⊙ Town

1 2 3 4 5 6 Scale

COUNTIES.

VAN WERT
PUTNAM
ALLEN
AUGLAIZE
MERCER
SHELBY
DARKE

OHIO.

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and 8 there is a pool having a length exceeding one mile, and a width less than one-half mile. Another small pool runs northeast and southwest through sections 1, 11 and 12. The length of this approximates two miles, and the width one-half mile. The largest of these outlying pools extends nearly north and south through sections 3, 9, 10, 15, 16, 21 and 22. Its area, however, does not exceed two square miles.

German Township.—Two pools are found in this township, a small one lying near the eastern line and including the larger part of section 13 and parts of 14 and 24; the second and larger pool lies principally in the northwestern corner of the township. It has a length of four and one-half miles, a maximum width of one and one-half miles, and includes parts of sections 7, 8, 9, 10, 11, 15, 16, 17 and 18. Enclosing as it does the village of Elida, this territory will be called the Elida pool.

Tests were first made in the vicinity of the village just named at an early day, probably in 1886. However, the object was natural gas, and when instead of this a small quantity of oil was found the wells were abandoned. Not until about 1895 was work resumed, when a 40-barrel well was secured. Since that year drilling has been in progress, and bids fair to continue for some time.

Marion Township.—From German township the Elida pool extends due west into Marion, where it includes parts of sections 2, 3, 10, 11, 12, 13 and 14. Considerable drilling was being done in the southeastern part of this township in 1902, and it is probable that the areas as above outlined are not now complete.

In the southwest corner of the township in sections 11, 12 and 7 and 8 an extension of the Spencerville pool is found.

Much of the work done in this township has been recent, and not improbably considerable drilling remains to be done.

Amanda Township.—In the northeastern corner of this township a small extension of the Elida pool is found. It includes parts of sections 23, 24 and 26. The southeastern corner of the township contains an extension of the producing territory in Auglaize county. Parts of sections 11, 12, 13 and 14 are included in this. Another small extension from Auglaize county is found in the southwestern corner of section 16. A small pool is found in the northern part of the township in section 21. Along the west side of the township is found a part of the Spencerville pool. It includes parts of sections 7, 8, 6, 31 and 30. Outside of these pools many wells have been drilled, so that it does not seem probable that important extensions will be made.

Spencer Township.—This contains 21 square miles, at least one-half of which is productive. The territory includes the whole or parts of sections 10, 11, 12, 1, 2, 3, 4, 35, 36, 25, 26, 22, 23, 24, 13, 14 and 15. The northern half of the town of Spencerville lies within this belt, and for that

reason the pool is called the Spencerville. On the east it extends into Amanda township, on the north into Marion, and on the west into Van Wert county.

About the year 1886 a well was drilled near the town of Spencerville. The result was a good flow of gas, which was piped to the town. In 1902 the town's reliance was on five wells, three of which were on the southeast quarter of section 26 and two on the southwest quarter of section 8, Amanda township. All produced some oil with the gas. The Trenton in these lies 6-7 feet higher than that in the adjacent oil wells. The supply originally was derived from wells lying south and southeast of town. Later the fuel was piped from Auglaize county. In 1902 the company supplied about 100 houses, charging 25 cents net per thousand cubic feet.

Oil was discovered in the vicinity of Spencerville almost as soon as gas, and drilling has been in progress irregularly since that time. Whenever a good well located outside of the producing territory was drilled, other wells were at once begun, and in this way a small boom developed. Periods of activity were reported in 1886, 1895, 1899 and 1902.

Very little work is now being done. Many wells have already been abandoned, and others are so small that they hardly pay for pumping. The township has long passed its zenith, and the production is slowly but surely declining.

Wells Drilled.—The following table shows the number of wells drilled in the county from 1891 to 1899:

Year.	Producers.	Dry.	Total.
1891	85	11	96
1892	35	3	38
1893	16	4	20
1894	50	13	63
1895	168	47	215
1896	174	52	226
1897	169	43	212
1898	226	43	269
1899	689	96	785
Totals	1,612	312	1,924

This shows 83 per cent producers and 17 per cent failures.

GEOLOGY OF THE COUNTY.

The surface of Allen county presents considerable variation. The western and northwestern parts are flat; the northeastern gently undulating; and the southern rather hilly, owing to the presence of a well-developed moraine.

The succession of strata underground at Lima is shown by the following record:

	Feet.
Drift	7
Lower Helderberg, Niagara and Clinton limestones	333
Clinton shale	40
Medina shale	50
Cincinnati (Hudson River) shale	470
Utica shale	350
Trenton at	1,250
Gas at	1,256
Oil at	1,260
Salt water at	1,272

Next is given a record of the Shull well, the pioneer at Beaver Dam, in the northeastern corner of the county. The well head was 860 feet above tide:

	Feet.
Drift	33
Lower Helderberg and Niagara limestones	247
Clinton limestone	40
Clinton shales	105
Medina shales	50
(475 feet of casing.)	
Cincinnati (Hudson River) shales	580
Utica shales	273
Trenton at	1,303
Bottom of well	1,345

Finally there is given a generalized section in the Spencerville pool, lying along the west line of the county:

	Feet.
Drift	5- 50
Limestones	300- 325
(Casing 360-380 feet)	
Shales	800- 850
Trenton at from	1,170-1,227

These and other records of a like nature show that the Trenton rock in Allen county lies highest in the southwestern corner. At Spencerville the formation is 328 feet below sea level; at Delphos, about 9 miles due north, it has dropped to 453 feet, about 14 feet to the mile. At Lima the Trenton lies about 390 feet below sea level, but at Elida, 6 miles to the northwest, the rock is 34 feet lower. At Beaver Dam, in the northeast corner of the county, the rock lies 443 feet below tide level, while due east of Lima, along the western line of Hardin county, the Trenton is found at about 470 feet below sea level.

It appears that a low fold extends across the county, running from Spencerville due east to Lima; thence northeast to Beaver Dam, and continuing in that general direction enters Hancock county. The fold is nowhere sharp; in fact, following from well to well gives the impression that the rock lies practically flat.

Around Beaver Dam it has been the custom to drill from 50 to 100 feet in the Trenton, but the oil and gas are usually found at depths not exceeding 35 feet. It is a general rule that the top of the rock in question is free from the desired products. The territory in this part of the county is quite spotted, due apparently to changes in the texture of the rock. The wells are shot with from 120 to 240 quarts of nitro-glycerine. Casing is inserted when the shales above the Clinton limestone are reached; in the language of the driller, the casing extends into the second break.

In the vicinity of Lima the drift is quite spotted, and sometimes very deep. The suddenness of the changes in depth shows that the underlying limestones have been deeply notched before the drift was deposited. This work was done by running water, and these unusual depths of drift are in preglacial valleys or gorges. One of these apparently starts a mile east of Lima, and extending southwest enters Auglaize county near Cridersville. The other heads near Elida and running slightly east of south unites with the first one near the county line. The greatest depth of drift reported in any of these old valleys is 394 feet, while outside of the valley the depth is usually less than 100 feet, and commonly does not exceed one-half of that.

What has been said with reference to the territory around Beaver Dam applies equally well to other parts of the county, for the geological relations are decidedly monotonous. Practically everywhere in the county some salt- water is pumped with the oil, but the quantity varies from place to place. Occasionally it is necessary to keep the pumps working day and night to keep the salt-water under control, a condition most common in the territory recently developed.

Production of the Wells.—Large wells have been secured in this county, but the greatest have not equaled those found in Wood. The first large well was drilled near Lima in the fall of 1887, and produced nearly 1,000 barrels of oil the first 24 hours. Six months later, when it had yielded 60,000 barrels, the production was still 150 barrels per day. A little later a well was drilled on the Ridenour farm in section 18 of Perry township which produced 2,760 barrels of oil during the first 24 hours.[1] This is the largest initial production in the county of which the writer has learned. In the northeastern part of the county the best wells started at about 500 barrels, but the number of these was small. On the west side of the county the best well reported yielded 600 barrels the first 24 hours.[1] No figure can be given for the average production, but it seems

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 178-9.

safe to say that by far the greater number produced from 25 to 100 barrels during the first day. The staying qualities of the wells have varied considerably in different places. Around Spencerville one well at least drilled in 1887 was still producing in 1902. At other points the decrease has been so rapid that the wells have hardly been profitable. An example of this sort is found in the pool in the southeastern part of Amanda township.

All parts of the county have now been tested, and it seems safe to predict that no large production of oil or gas will be discovered, though a trace of either or both may be found almost anywhere that a well is drilled.

AUGLAIZE COUNTY.

Oil territory in this county is very scattered. A few large pools are found, and many small ones. The great Lima field extends into the northern part, and the productive territory continues interruptedly southwest across the county, passing into Mercer on the west and Shelby on the south. Nine townships are included in this belt.

Duchouquet Township—The Lima pool extends into the northern part of this township, and includes the whole or the part of sections 31, 32, 33, 34, 35, 36, 2, 4, 5, 6, 7, 8 and 17. The tier of sections along the county line is occupied quite largely by productive territory, but other sections have simply a narrow arm passing through them.

Drilling in this township was begun in 1885, the object being natural gas; but in this, as in so many other places, the effort was unsuccessful. Oil was discovered by attempting to extend the Lima field into Auglaize county. Much of the territory is now very old, the wells averaging from one to two barrels per day. New wells start at from five to fifteen barrels. Strong efforts have been made to extend the pool, but unsuccessfully. It seems safe to say that this township has passed its zenith, and that many of the wells will soon be abandoned.

Logan Township.—The oil territory in this township is very spotted. In the northeastern corner an extension of the Allen county field occupies parts of sections 23, 24, 25 and 36. In the northwestern corner a small pool, having a length of one mile and a width of a small fraction of that, occupies parts of sections 19 and 20. The principal territory, however, is in the central and southern parts of the township, comprising parts of sections 26, 27, 28, 29, 31, 32, 33, 34, 2, 3, 5, 6, 7, 8, 10, 11 and 12. Examination of the map will show at a glance the exceedingly irregular nature of the territory. The barren strips that are partially surrounded by productive areas are to be classed with similar ones in Wood and Sandusky counties.

The territory began to be developed in 1888, the first well having been drilled on the Gochenour farm in section 11. It started at 250 barrels, and other wells drilled in the same neighborhood gave equal or still better results. Two wells located on section 15 started at 600 barrels.

These results, however, were unusual, the greater number by far starting at less than 100 barrels.

The size and shape of this territory has changed considerably in the past three years; this has resulted principally from abandoning many small wells, but at several points new ones have been drilled, thus producing extensions at these places.

Moulton Township.—This lies south of Logan, and contains an extension of the territory in that township; besides this several smaller and independent pools are found. The producing sections include parts of 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 26, 28, 29, 35 and 36.

However, the total area yielding oil is very small in comparison with its wide distribution. The development and history of the township are similar to Logan, and consequently will not be related here.

Washington Township.—In the northwestern corner of this a small pool is found extending from Moulton township into sections 1, 2 and 3. Another long narrow strip is found on the western side in 7, 8 and 9, from which it extends into Noble township. A few wells are found on the western side of section 6 also. These wells are small, and the production of little importance.

Salem Township.—The only producing territory in this township is along its borders, where extensions are found from adjacent townships. In the extreme northwestern corner a few wells are found; and the same is true in sections 6 and 31 on the west side, and 1, 4 and 5 on the south side. The entire production in this territory does not exceed one square mile.

Noble Township.—The oil territory extends northwest and southeast entirely across the township. Throughout a considerable portion of this belt the width is two miles or more. From this several narrow tongues branch to the east and west. In the southwestern corner of the township production is found in section 31 and to a small extent in 30 and 32. The territory in this township extends south into St. Marys, north into Salem and west into Mercer county.

Besides the sections named the producing belt includes parts of 7, 8, 9, 11, 12, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34 and 35.

This township comprises the larger part of the St. Marys oil field. Development began in 1888 and proceeded rapidly. In 1893 work was resumed with renewed vigor, and since 1900 has again been quite active. Numerous efforts have recently been made to extend the territory, but in the main these test wells have been failures. Many of the earlier wells have been abandoned, and the remaining ones are nearly all small.

St. Marys Township.—The two pools, previously mentioned as extending from Noble into St. Marys township, cross the latter as two narrow belts and then enter Washington, where they disappear entirely. The

northern one includes parts of sections 1, 2 and 3; the southern one parts of 6, 5, 4, 8, 9, 16, 10, 15, 11, 14, 12 and 13. The western end of this includes part of the Grand reservoir. Another pool is found in the southwestern corner of the township. It extends from the southeast corner of the reservoir nearly to the German township line, including parts of sections 19, 20, 28, 29, 33 and 34. Its maximum width is less than one mile. A few wells are found near the middle of section 32.

Work in this township began in 1886, the search being for gas. Both oil and gas were found in the pioneer well, but neither in large quantities. Later wells gave more favorable results, and for some months natural gas was the feature of the township. However, it was soon found that the real wealth lay in oil and not in gas. By 1890 the productive territory had been pushed to the eastern border of the Grand reservoir, and a year later wells were being drilled in that body of water. Those near the reservoir are reported to have been large—one or two with an initial daily production of 1,000 barrels or more. Those within the reservoir were smaller, owing probably to the adjacent wells having partly drained the underlying oil-rock. Many of these wells have already been abandoned.

The pool in the southwestern corner of the township dates back to the days of testing for gas. Fine oil wells were secured; the initial production of many ranging from 100 to 200 barrels, and the settled production from 25 to 50. In recent years the best of the wells drilled did not start at more than 25 barrels, and in 1902 the average daily production of the wells in the pool did not exceed one barrel.

German Township.—The oil territory here is very small; a few wells are found in section 4 in the northern part of the township, and in the southeast corner a narrow strip extends across section 13, running into Van Buren township (Shelby county) on the one hand and into Jackson township on the other. A few wells are found in section 13 also. Probably the entire productive area in the township does not exceed one-half of a section.

Jackson Township.—The narrow strip referred to above as passing into this township extends southwest, passing through sections 13, 14, 23, 22, 21, 28, 29 and 30. In the northwest corner of section 20 a small pool is found. This extends westward into section 19 and northward across the township line into section 17 of German.

While a few wells were drilled in both German and Jackson townships as early as 1887, the real work did not begin until 1896. Since that time much work has been done, and there seems little hope for the future, unless conditions are such that much smaller wells can be drilled with profit than at the present time. The wells are now rapidly approaching exhaustion, a large number having already been abandoned.

Wells Drilled.—The well record of Auglaize county for nine years was as follows:

Year.	Producers.	Dry.	Total.
1891	362	14	376
1892	157	19	176
1893	184	30	214
1894	298	50	348
1895	414	68	482
1896	246	62	308
1897	244	59	303
1898	195	44	239
1899	204	72	276
Totals	2,304	418	2,722

It is seen from this that 84 per cent. were producers and 16 per cent. dry.

GEOLOGY OF THE COUNTY.

The Niagara limestone forms the surface rock of the southern, northeastern and northwestern corners; the Lower Helderberg limestone of the north central part of the county. The topography is flat or gently rolling, except where the moraine is found. This extends from near the Grand reservoir northeast past Wapakoneta, and is the most striking topographic feature of the county.

No complete log of a well has been secured; the following is from near St. Marys:[1]

	Feet.
Drift	110
Niagara limestone	175
Niagara, Clinton, Cincinnati (Hudson River) and Utica shales	877
Trenton limestone at	1,162

At St. Marys the Trenton lies 313 feet below tide; at Minster about 260 feet, showing a fairly rapid ascent to the south. At Wapakoneta, in the central part of the county, the same rock is found at 348 feet below tide, and at Cridersville, in the northeastern corner, at about 360 feet.

Oil is found near the top of the rock only, all efforts thus far to locate a deeper pay having failed. The gas is small in quantity and is found with the oil. Salt-water causes little trouble. It lies deeper usually than the oil, so that the operator does not have to pump the brine, as he does when oil and water occupy the same rock.

A conspicuous feature of the county is a number of deep channels cut several hundred feet into the underlying rock. These undoubtedly

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 255.

represent the course of a river in pre-glacial times. The channel is filled with drift, and consequently wells in it require great lengths of drive pipe. One branch runs southwest from near Lima, past Cridersville, just west of Wapakoneta, to near the Shelby county line, where it unites with a channel that has been traced from near St. Paris, Champaign county, northwest past Anna into Auglaize county. The united channels run nearly due west from that point, passing through the Grand reservoir. Another channel is found in the southwest corner of the county, entering from Shelby on the south and extending into Mercer on the west.[1]

Nothing additional to what has already been stated needs be said of the size and production of the wells. It is apparent that the largest did not rival the giants found farther north. However, the average production was good, and the territory must be rated among the important in northwestern Ohio.

MERCER COUNTY.

Oil-producing territory in this county is badly scattered. Quite a number of pools are found, but the greater number of them are small. The territory enters the county from Auglaize on the east, and extends into Adams county, Indiana, on the west.

Union Township.—This lies in the northeast corner of the county, and has the largest area of producing territory. The latter enters the county from Van Wert on the north and Auglaize on the east. The producing territory includes parts of sections 1, 2, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 21, 22, 23, 24, 26, 27, 28, 34, 35 and 36.

Successful wells began to be drilled in the township early in 1893, and during the two ensuing years rapid progress was made. A well is still drilled occasionally, but the life of the field will be determined by that of the wells already completed.

Center Township.—One small pool lies within the township, including a small part of sections 3 and 4. Besides this there are several small areas along the eastern line, extensions from Union on the north and Auglaize county on the east. The sections included are parts of 1, 2, 12, 24 and 25. The history and development in this township has been similar to that in adjacent ones.

Jefferson Township.—The producing territory includes two small pools entirely within the township, and part of a third which extends into Center on the north and Auglaize county on the east. The sections included are parts of 1, 2, 4, 5, 11, 12, 32, 33 and 36.

Drilling in this township began in 1886, the first well having been sunk at Celina. It made a show only of oil and gas, but those interested did not feel satisfied and accordingly a second well was begun. This was

[1]For a detailed report of these channels, see Special Paper No. 3, Ohio State Academy of Science.

[2]*Geol. Sur. of Ohio*, Vol. VI, p. 259.

a complete failure.[2] Not until 1890 was oil secured in the township, and drilling has been done from time to time since that date. The largest of the earliest wells started at 250 barrels per 24 hours, but of course the average was much less. In the summer of 1902 the wells of the township averaged about one barrel only each per day, and many were being abandoned. The principal work during the year just mentioned was southwest of Celina. One well there started at 500 barrels per day, but a month later was yielding salt-water only.

Franklin Township.—The area in this is about the same as in Jefferson. However, by far the largest part lies almost entirely in the Grand reservoir. This pool has a length of about four miles and a maximum width of nearly one mile. Two additional pools, both very small, are found; one lies in the western half of section 23, and the other near the western line of 24. The area of the two combined does not exceed 40 acres.

Gas was discovered in the township late in 1886 or early in 1887 in section 24, near the Auglaize county line. Oil wells began to be drilled in 1890, possibly a little earlier. Progress was rather slow, owing to the difficulty of drilling in the reservoir. The township has been thoroughly tested, and it is probable that the production of oil will soon be a thing of the past.

Dublin Township.—The producing territory here does not exceed one-quarter of a section. It consists of three independent pools; one in section 5, another along the St. Marys river in the Black Loon reserve, and a third in the northwest corner of the township.

Black Creek Townsnip.—This contains a narrow strip along the state line. It has a length of three miles and a maximum width of one and one-half miles. The included sections are parts of 18, 19, 30, 31 and 32. From this township it extends into Indiana.

Wells Drilled.—The wells drilled in the county from 1894 to 1899 were as follows:[1]

Year.	Productive.	Dry.	Total.
1894	190	57	247
1895	218	43	261
1897	86	32	118
1898	80	10	90
1899	113	16	129
Total	687	158	845

This shows 81 per cent. producers and 17 per cent. failures.

GEOLOGY OF THE COUNTY.

Surface Features.—The surface formation of the county, with the exception of a small area in the northwest corner of Union township, where the Lower Helderberg is found, belongs to the Nigara. The topog-

[1]No data for year 1896.

raphy varies from flat to sharply rolling, the latter a product of glacial action. Two moraines cross the county from east to west; one of these lies in the southern part, the other near the middle. The latter seems to be the more conspicuous. Two principal streams, the St. Marys river and the headwaters of the Wabash, cross the county. These and their branches have broken the erstwhile flat portions of the county.

Underground Features.—The succession and thickness of strata below drainage are shown in the following record of a well drilled at Celina:[1]

		Feet.
Drift		70
Niagara limestone	Yellow 20 ft. White 65 ft. Drab 9 ft. Various shades 41 ft.	135
Niagara shales		15
Clinton limestone		43
Medina shales		20
Cincinnati (Hudson River) shales		480
Utica shales		310
Trenton limestone at		1,110
Bottom of well at		1,168

This makes the Trenton 235 feet below tide; near St. Henry, in the southern part of the county, the same formation is found at 205 feet (approximately) below tide. Examination of a large number of wells in various parts of the county shows the Trenton lying at about 1,090 to 1,200 feet. The changes are gradual, indicating the absence of an arch, at any rate of a conspicuous one.

Thus far the deeper pays reported in Wood and adjacent counties have not been reported in the county under consideration. The oil is commonly found at depths in the Trenton not exceeding 25 feet. The rock is hard and fine, so that the wells usually make little promise until after having been shot.

One of the striking geological features of the county is the preglacial channel already mentioned in connection with Auglaize and Shelby counties. It enters Mercer by two branches; one from the east runs west through the reservoir, the other from the southeast extends northwest through Franklin township. The two unite in the reservoir a short distance east of Celina, and extend northwest past Rockford and then slightly south of west into Indiana, where it has been traced through Adams, Jay, Blackford and into Grant county. This old channel has been the most serious obstacle that the driller has had to contend with in those counties.

Size and Duration of the Wells.—But little needs to be said on this subject, in view of what has already been given. Perhaps the largest well that has been drilled in this county was on the Murlin farm, section

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 259.

1 of Center township. This is reported on seemingly good authority to have had an initial production of 1,200 barrels of oil per day, maintaining that rate for several weeks. It gradually decreased to 500 barrels, but continued producing at about that rate for some time. At present (August, 1902) it is very light. The well was drilled in 1895. Several wells in Union township started at from 600 to 800 barrels per day, and a large number at 100 or more. The gravity of the oil there is 38 degrees B. Other pools in the county made a poorer showing than that in the northeast corner. It has been found that the flowing wells were shorter lived than those which contained large quantities of salt-water. Taking the territory as a whole it is safe to say that it is long past its prime. Wells are being abandoned in comparatively large numbers, and the production of the county bids fair to decrease rapidly.

LUCAS COUNTY.

Early tests in this county were made for natural gas, and the results have already been given in the discussion of that fuel. Oil was found at a considerably later date. The territory is small, so that if it had never been discovered the production of the Trenton limestone field would not have been materially changed. Three townships contain oil; two of these lie east of Toledo and one west. A showing of oil can be secured at many places outside of the producing territory.

Monclova Township.—The territory here forms a strip extending from the Maumee river nearly due north, including parts of sections 32, 33, 28, 29, 20, 17 and 8. In width the strip nowhere exceeds one-half mile. It is an extension of the territory in the western part of Wood county.

Oregon Township.—This contains by far the larger part of the producing terrritory in Lucas county, including the whole or parts of sections 22, 23, 24, 19, 25, 26, 27, 28, 30, 31, 36, 35, 34, 2, 3, 5, 6, 7, 8, 11, 12, 18, 13, 14.

That the county contains oil in paying quantity seems to have been demonstrated for the first time about 1891, when a well was drilled on the Blodgett farm in section 2. The well was of the flowing type, but the oil was mixed with water, making the former of bad quality. Other wells were drilled about that time, but without marked success. The real production began with the completion of the Bartley well on section 2 in 1896. This well, according to Shafer Brothers, the drillers, had an initial production of 500 barrels of oil per day. The rock was shot later, but without beneficial results. Naturally a production of this type started considerable excitement, and greatly stimulated drilling. One year later a well was drilled that completely eclipsed the Bartley. This was the "Klondyke," situated in a marshy valley along the border of Irondale. The location was made by a forked stick, and when the Trenton had been penertated 48 feet there was no show of oil or gas. The rock was then

shot with 120 quarts of nitro-glycerine, and oil began flowing at once. Tanks had not been provided, and the oil wasted for five hours. The first tank completed had a capacity of 250 barrels, and was filled in one hour and fifteen minutes. Then again the oil ran into the creek, and wasted. Seven hours later adequate tankage was provided. The well flowed during 12 days. In June, 1902, its production was 14 barrels per day. Other wells were at once begun in this vicinity, but all were small or failures; the second one, located about 500 feet from the "Klondyke," started at 3 barrels, and was abandoned one month later. The "Klondyke" gave the territory great advertising, and as a result wells were rapidly drilled. In 1902 work was being done at several localities, but no important additions were discovered.

Jerusalem Township.—The producing territory in this township is small. In sections 4 and 33 a small pool is found. Its length is about 2 miles and its maximum width less than one-half mile. A small pool crosses the southwest corner of section 9, extending southeast into Ottawa county, and northwest into section 8 of Oregon township, Lucas county. Immediately north of the west end of this pool another small one is found. It occupies parts of sections 4 and 9 of Jerusalem township and 5 and 8 of Oregon. From what has been said it is evident that the production of oil in this township is very small.

GEOLOGY OF THE COUNTY.

The topography is as flat and as uniform as is found in any county of the state. Along the lake shore there are extensive marshes, some of which have recently been drained, bidding fair to make excellent farming territory. The surface rocks in the eastern part of the county are principally Lower Helderberg, but the geological map of the state shows a narrow belt of the Niagara extending due north from Geneva to the lake, which is reached at Cedar Point. This belt, as sketched, lies east of the principal oil territory. The western part of the county has as surface rocks the Lower Helderberg and Corniferous limestones and the Ohio shales.

The Oil-rock.—The Trenton in the producing territory of the eastern half of the county lies from 740 to 800 feet below sea level. It is very unusual that oil is found at such depths in northwestern Ohio. The rock lies highest over the low fold which brings the Niagara to the surface. From that belt the Trenton dips east and west, and at the same time to the north, the greatest depth having been reported along the lake shore.

As a rule the oil-rock is penetrated 50 feet. Sometimes the oil is found at the top, but usually it lies below the so-called cap-rock. Shooting nearly always helps the wells; charges used range in size from 60 to 300 quarts.

Salt-water has never been a serious obstacle in the county. In fact, that found has generally been regarded as beneficial.

The life of the wells has presented considerable variation. Those near Ironville have in the main been remarkably short, some having been abandoned in a few months after completion. The wells farther east produce longer, and may rival in this respect the best territory in other counties.

OTTAWA COUNTY.

Drilling in this county began in 1886, the first well having been completed July 5. It was located at Oak Harbor, and the Trenton limestone was struck at 1,300 feet, or 720 below sea level. The well made a showing of oil and about 78,000 cubic feet of gas per day. Another well completed shortly afterwards met with still less success. Well No. 3, drilled late in 1886, yielded about 200,000 cubic feet of gas in 24 hours. A line was laid to the village and the use of this fuel begun.[1]

From that early period, drilling has been done from time to time in the vicinity of Oak Harbor. The supply of gas has been continuous, but it is no longer adequate to meet the demands of the town. During the first six years the rate was 20 cents per thousand; then it was advanced to 30 cents with a possible rebate of 5, and 1902 was 35 cents straight.

In section 9, southeast of the village, 13 producing wells have been secured. These are about equally divided between gas and oil. The first of the producers of oil was drilled in 1898, and started at about 12 barrels per day; most of the others were sunk in 1899 and 1900. In 1902 the average daily production per well was about one and one-half barrels. Three small oil wells have also been secured about one mile east of Oak Harbor, on the north side of the river.

A number of additional tests of the Trenton have been made in this township; one on the Fred Miller farm, one and one-half miles southwest of Oak Harbor, made a showing of gas; one on the Applegate farm in section 8 gave a similar result; and the same is true of wells drilled on the Vogel farm in section 11, and on the Kreilich in section 20.

Several wells have been drilled in the vicinity of Port Clinton, and while all made a showing of oil or gas, none yielded these products in commercial quantities. The first of these wells, drilled in the winter of 1886-7, found the Trenton at about 1,080 feet below sea level. North from Oak Harbor the Trenton drops 100 feet in two and one-half miles.

Between Trowbridge and Limestone, in Benton township, a number of strong gas wells have been secured. The roar of the escaping gas could be heard at Oak Harbor, several miles distant, but salt-water soon ruined all.

At Elmore in Harris township a test was made in pioneer days of the industry in northwestern Ohio. The first well was dry, but the second

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 210-1.

yielded a little oil, enough to attract attention and to secure further tests. A number of wells have been sunk between Elmore and Oak Harbor, and oil secured in some, but all have now been abandoned.

Similar, though perhaps little better results have been had on the western side of the county. A well drilled at Geneva in 1887 found the Trenton at 660 feet below tide, and made a showing of oil with more gas. Just north of the village a number of wells have been drilled, the first about 1891. The rock pressure at that time is reported to have been about 225 pounds per square inch. Since 1892 the gas has been used in the village. Nearly a dozen additional wells have been drilled near this village, but all were dry. In the northern part of this township two pools of oil are found. One lies just east of Curtice, including parts of sections 8, 33 and 34; the other is longer, including parts of 14, 15, 26, 27, 34, 35, 2, 3, 10, 11 and 14.

WYANDOT COUNTY.

The oil territory in this county extends from near Carey southeast within two miles of Upper Sandusky, and as shown by the map consists of several small pools, two of which number less than a half dozen wells each.

Crawford Township.—This contains two small pools and part of a large one, the latter lying principally in Salem township. In 1902 the productive territory was limited to sections 20, 27 and 35, but formerly it was considerably larger.

Work began at an early day, probably in 1886. Here as elsewhere the search was for natural gas. The Trenton limestone was found at 1,326 feet or 513 feet below tide level, and a small flow of gas secured. Other wells, drilled in the same locality, gave better results and consequently the village soon had an adequate supply of gas. About 1888 oil was discovered on the Kinley farm, section 1 of Salem township, and from that point the drill moved north into Crawford. Drilling has been done from time to time in the township ever since. Probably 50 per cent. of the producers have now (1902) been abandoned, and doubtless others soon will be. Over 40 dry holes have been sunk, so that it is safe to say that the township has been thoroughly tested.

Salem Township.—This township lies south of Crawford. The producing territory includes parts of sections 1, 2 and 12. As has already been stated oil in Wyandot county was first discovered in this township, and from here the drill moved into adjacent townships. The initial well flowed about five hundred barrels per day; in 1900 it was yielding two barrels, and was still producing in 1902. About 1890 a well drilled on the Krebs farm, section 1, began flowing at the reported rate of 1200 barrels of oil per day, making it the largest ever drilled in the county. In July, 1902, its daily production was two barrels. Work has been done from time to time in the township since oil was discovered.

Crane Township.—Early in 1886 the Trenton was tested at Upper Sandusky and found dry. Later oil was secured in sections 6, 7 and 19; that in 6 and 7 is an extension of the Salem township pool; and that in 19 is a small outlier. The dry holes have been more numerous than the producing wells; consequently the township has added little or nothing to the wealth of the country.

GEOLOGY OF THE COUNTY.

The surface of the county is level or gently undulating. On the western side the Niagara limestone forms a narrow strip running north and south. On the eastern side there is a parallel strip about equal in width of the Corniferous limestone, and between the two a broad area of the Lower Helderberg. The succession of strata underground at Carey is as follows:[1]

	Feet.
Drift	2
Lower Helderberg and Niagara limestones	257
Niagara shale and Clinton	65
Medina shales	52
Cincinnati (Hudson River) shales	650
Utica shales	300
Trenton at	1,326

The Trenton was found to lie 515 feet below tide level; at Upper Sandusky it is about 480 feet below, and at Nevada, near the Crawford county line, about 830 below This shows a rapid descent east from Upper Sandusky. In fact the rocks of the county appear to lie quite uneven. Thus from what has been stated above it is seen that at Upper Sandusky the Trenton lies 35 feet higher than at Carey, though the former place lies east and south of the latter. This indicates an arch in the vicinity of Upper Sandusky. Another disturbance is found in section 34 of Crawford township, where the Trenton is reported to vary in position 100 feet in less than a mile.

In the vicinity of Carey the Trenton was found to be quite free from salt-water, but about one mile southwest of that town a heavy pool of brine was encountered, that sometimes ran from the well. Fine oil wells were secured in this. Southeast from Carey brine was found almost everywhere. The water and oil were mixed, and consequently were pumped together.

VAN WERT COUNTY.

Oil territory in this county is not extensive, notwithstanding that it is found in five townships. The Allen county fields extend into Van Wert from the east and the Mercer from the south. Early wells were drilled wholly for gas, and were practically failures.

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 204.

Jennings Township.—This has the largest area of producing territory in the county. The Allen county fields extend into this township at three points; sections 4 and 9, 21, 4 and 34, but the combined areas of the three do not exceed one square mile. In the northeast corner of the township a much larger area is found, comprising parts of sections 6, 7, 8, 17 and 18. This extends west into York township, and is known as the Venedocia field. In the southwest corner of the township under consideration an extension of the Mercer county territory is found. This comprises section 7 and parts of sections 5, 6 and 18. The Trenton is found usually at depths ranging from 1,175 to 1,200 feet.

The development of this township began about the year 1890. Early wells showed much salt-water, and this discouraged drilling. However, oil men finding that the brine could be handled, made further tests and were successful. By 1896 work in the northwestern corner of the township had ceased, but was renewed in 1900. The territory in the southwest corner forms part of the Menden field. This township has now been thoroughly tested, and no important addition needs be looked for. However, when the day arrives so that small wells which cannot now be operated with profit can be so operated, then considerable drilling may again be done. Many of the pioneer wells have been abandoned, and it appears that the township is now past its prime.

York Township.—In the northeast corner of this township producing territory is found in sections 1, 2, 3, 11, 12, 13 and 14, but the area is only about two square miles. In the southeast corner a small extension of the Menden pool is found in sections 25, 35 and 36. About three miles due west of this a very small pool is found in section 33. The oil rock is found at depths varying ordinarily from 1,180 to 1,225 feet.

Work in this township began near Venedocia, in the northeast corner about 1890, and has been continued irregularly ever since. Since 1900 many wells have been drilled in that vicinity, and as late as the summer of 1902 work was active. Many of the early wells have already been abandoned. The late wells commonly have an initial production ranging from 15 to 25 barrels per day. The territory in the southeast corner of the township was drilled late in the history of the Menden field.

Ridge Township.—Oil territory in this township is restricted to the southeast corner, where it occupies small parts of sections 33, 34, 35 and 36. The total area is less than one square mile. It comprises the northern part of the Venedocia field. In sections 28, 21 and 20 several gas wells are found. These supply Van Wert, as has been stated elsewhere in this volume. The first oil well in the township was drilled in November, 1901.

Liberty Township.—This contains several small pools, the combined area of which does not exceed two square miles. One of these extends across the township line into Willshire. In the extreme southwest corner of Liberty there is found a very small extension of one of the Mercer coun-

ty pools. The sections are 26, 27, 34, 21, 16, 17, 18, 20, 19, 30 and 31. These wells have been drilled comparatively recently. The depth to the Trenton is similar to that in Jennings and Liberty townships.

GEOLOGY OF THE COUNTY.

The conspicuous surface features of the county are two in number; one of these is a beach of glacial-lake Erie, which extends across the northern part of the county. This is a low ridge of sand and fine gravel rising a few feet above the general level. The second feature is a moraine extending east and west across the south side of the county. This is a ridge of clay and gravel, and while rather flat is still considerably higher and wider than the lake beach. With the exception of these two cases the topography of the county is exceedingly flat. The surface rocks in the southwest corner belong to the Niagara, those in all other parts to the Lower Helderberg.

The following record of a well at Van Wert shows the succession and thickness of strata:[1]

	Feet.
Drift	32
Waterlime (Lower Helderberg)	148
Niagara limestone	185
Niagara shales	15
Clinton limestone	40
Medina and Cincinnati (Hudson River) shales (blue)	510
Utica shales (dark)	290
Trenton at	1,220

The top of the Trenton was found at about 435 feet below tide level. In the eastern part of the county, near Delphos, the same formation was found at 453 feet below tide. This shows the Trenton lying nearly horizontal. Comparing these figures with those found at Celina, in the county to the south, shows a dip northward of about 200 feet. Even this, however, is a very gentle descent. It appears from what has been said that the position of the Trenton rock in this county corresponds very closely with that found in adjacent counties. The depths at which the formation is struck ranges ordinarily from 1,120 feet to 1,260. The pay-rock is comparatively shallow, being found ordinarily at depths of less than 35 feet in the Trenton. Thus far deeper pays have not been found, though no extensive search has been made for them.

Much of the oil found is of poor quality, having a very dark color, and high specific gravity, the latter dropping to 35 degrees B., and occasionally still lower. The size of the wells has been in keeping with the quality of the product. Rarely has the initial production reached 200 barrels per day. The life of the wells appears to be shorter than in the coun-

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 239.

ties farther east, so that, all things considered, Van Wert cannot be regarded as having contributed materially to this form of wealth.

Salt-water has been found very generally with the oil. Sometimes it has been so abundant as to prove an expensive obstacle. The county appears to form the border on the northwest for oil production, and possibly this may be responsible for the discouraging features named.

Many efforts have been made to develop a large pool in Van Wert county, but without success. Nearly everywhere a show of oil or gas is secured, and this has kept the drill busy. Probably other small pools will be discovered, but it is safe to say that no large areas will be found.

SHELBY COUNTY.

The only oil or gas producing territory in this county is found in sections 7, 18, 6, 8, 5, 4, 11, 32 and 33 of Van Buren township. The length of the pool is three and one-half miles, and the maximum width three-quarters of a mile. The pool is an extension of that found in German township, Auglaize county, and was opened in the summer of 1898. At first a few of the best wells started at 100 barrels per day, but so rapid has been the decline that in August, 1902, the pool did not average one barrel each per well.

In 1897 two wells were drilled near Kettlerville, on the south side of section 11. One of them began flowing 100 barrels per day, and a year later was producing 10 barrels. In the summer of 1902 it was yielding three barrels daily. The other well was smaller. No salt-water was found. One of these wells found 500 feet of drift and the other 380 feet.

On the margin of the producing territory salt-water is very abundant; but near the center of the pool where as a rule the best wells are found it is much less troublesome. The rock is quite spotted, dry holes being scattered among producing wells. The Trenton appears to lie nearly level. The oil is very dark and heavy, its specific gravity being 34 degrees B.

As has already been noted in the discussion of Auglaize county, the deep pre-glacial channel, which has been there outlined, extends across the northeast corner of this county. It is shown by drive pipes from 300 to 400 feet or more in length.

DARKE COUNTY.

Near Yorkshire, in the northern part of the county, several small oil and gas wells have been secured. The drilling was done in 1897-8. Owing, however, to the low price of oil the wells were not profitable. Quite recently the territory has been re-leased, and it seems probable that it will be thoroughly tested in the near future. Wells have been sunk at numerous localities in the county, but the results in all cases have been unsatisfactory.

PUTNAM COUNTY.

A small pool of oil has been discovered in the southeastern corner of this county. It occupies part of section 26, Riley township, and the development began in 1896. Drilling has been done from time to time since that year.

The Trenton is reached at from 1285-95 feet, the oil lying near the top of the formation. About 450 feet of casing are used. The largest wells had an initial production of perhaps 65 barrels per day. Near the margin of the pools the wells were much smaller, and the production of brine correspondingly larger. From the dry holes sunk it seems probable that the area of productive territory has been determined, and consequently very little can be expected in the future.

Tests were made at Ottawa and Columbus Grove in 1885, and Leipsic and Kalida in 1886. All were failures as far as securing oil or gas in commercial quantities was concerned. Since that time many wells have been drilled in the county. Nearly every township has been tested. and in several a number of wells have been sunk. Frequently a show of oil or gas was secured, but there has been practically nothing to compensate for the time and money expended. It seems safe to say that no large reservoir of oil or gas can be expected in the county. It may be, however, that in years to come, when the price of oil is much higher than at present, that the rocks in Putman county will yield a profitable supply of crude oil.

PAULDING COUNTY.

In the summer of 1902 two small oil wells were drilled near the town Paulding, and four gas wells had previously been completed southwest of that town. These supply the place named with fuel. In all probability the Trenton limestone in the county under consideration will be found to contain quite commonly small but unprofitable quantities of oil or gas.

CHAPTER III.

THE CLINTON FORMATION AS A SOURCE OF OIL AND GAS.

Introduction.—Oil or gas has been secured in these rocks at a number of places. In the main, however, the yield has been very small, often a mere showing. The only pool of oil having commercial importance that has yet been discovered lies in the northern part of Vinton county, and the reader is referred to that county for details. A small well has been secured between Junction City and New Lexington, in Perry county, and another well is now under way. Small flows of gas have been secured in the Clinton at a number of points in northwestern Ohio, especially at Fremont, Sandusky county. A few scattering wells have been drilled in Vinton county, but the one important field lies in central Ohio. No further notice wil be given the scattering wells in this chapter, and hence the theme for discussion is the fields in the central part of the state.

THE CENTRAL OHIO NATURAL GAS FIELDS.

Four fairly distinct reservoirs of gas have been discovered in central Ohio. However, their geological relations are similar, while geographically they are closely related, and for these reasons all will be considered together. In other words the several reservoirs will be regarded merely as parts of one large field.

Location and Area.—At the present time these fields consist of two parts, a southern one commonly known as Sugar Grove, and a northern one known as Homer. Between these, two additional reservoirs have been discovered, but both have long been exhausted. One lay at Thurston, Fairfield county, and the other in the vicinity of Newark, Licking county.

By far the most important reservoir is that surrounding the village of Sugar Grove. It includes portions of the following townships in Fairfield county; Pleasant, Berne, Rush Creek and Madison. In the last two, however, very few wells are found. Hocking county, lying to the south, has producing wells in the following townships; Good Hope, Laurel and Marion. The length of the field as developed in 1902 was 16 miles, and the maximum width 11 miles. The longer axis runs north and south. Lying north of this field is that of Thurston, which as has already been stated, has long been exhausted. Continuing due north the old Newark

field is skirted along its western edge, and finally the Homer reservoir reached. The latter as developed in the fall of 1902 contained parts of Burlington, Bennington, Washington and McKean townships of Licking county, Milford, Miller and Morgan townships of Knox county. A well has recently been drilled in the northwestern corner of Clay township, and one in the northern part of Union.

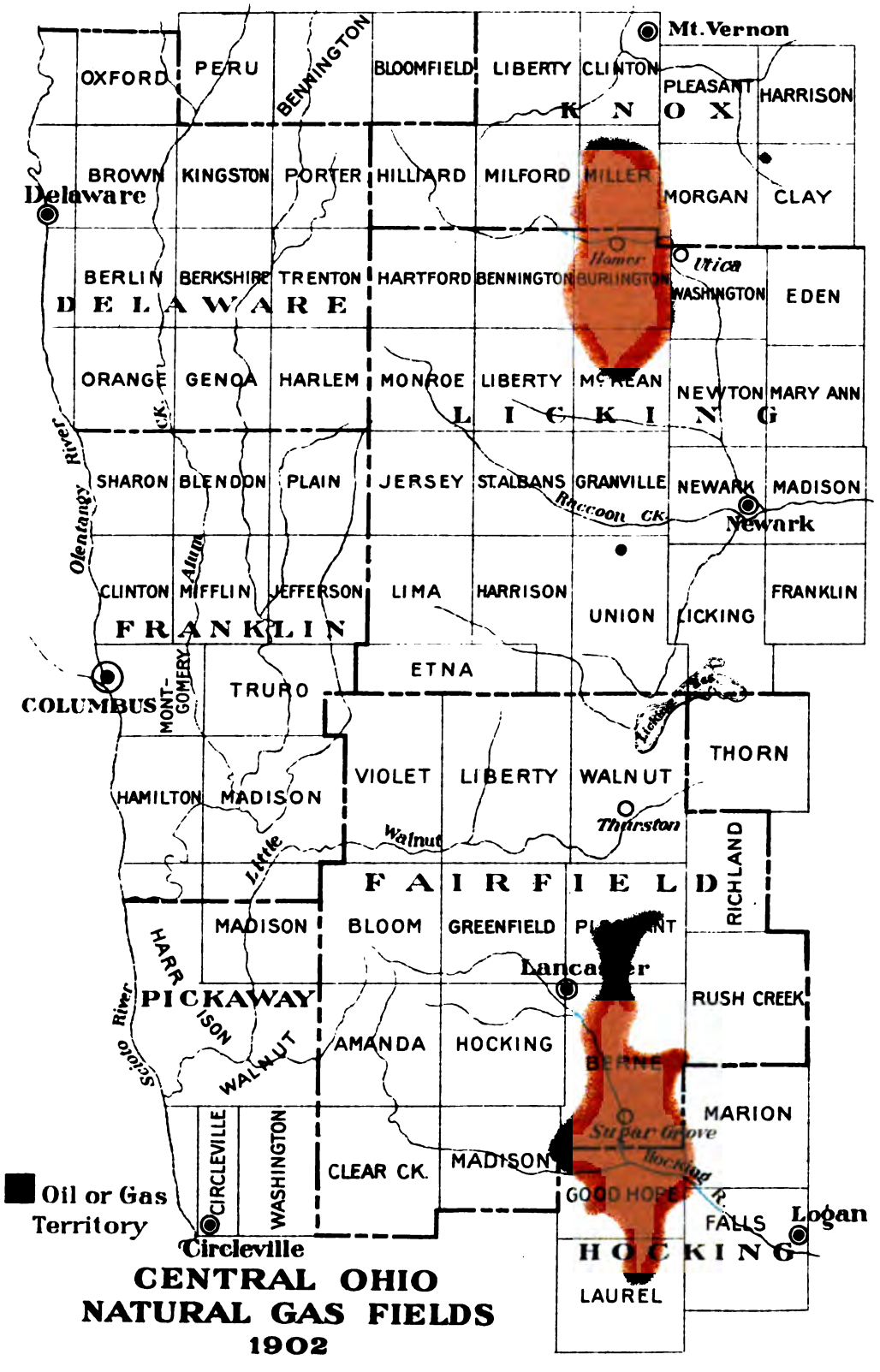
It is evident from what has been said that the gas fields of central Ohio extend north and south, the distance being about 60 miles. It must not be understood, however, that at any one time the producing territory has formed a continuous strip of this length. It is worthy of note at this point, that in the northern part of Vinton county, about 12 miles south of the southern limit of the gas belt, a small pool of oil has recently been discovered in the Clinton sand. Still later a small oil well has been secured in the same formation near Junction City, about 20 miles east of Lancaster.

History and Development.—No other event in the history of Ohio has so stimulated the search for underground wealth as did the discovery of natural gas at Findlay in 1884. From that city the drill has moved out in all directions until every county in the state has been tested; in some the wells may be reckoned by the score, yes, by the thousands. In the main these tests have produced negative results only, and still they have formed the basis of two of the state's principal sources of wealth. The Findlay discovery was followed in 1885 by tapping the immense volume of oil stored in the Trenton limestone, and two years later by the discovery of gas at Lancaster.

The first step towards testing the rocks in the vicinity of Lancaster was taken December 2, 1885, when the Lancaster Natural Gas Company was incorporated.[1] The capital stock was $50,000 in shares of $50 each. On the date just mentioned the company organized by electing the following officers: President, E. L. Slocum; Vice-President, A. Getz; Secretary, H. B. Peters; Treasurer, N. Butler.

The directors included, in addition to the officers, H. C. Drinkle, J. R. Mumaugh, J. G. Reeves, E. Becker and George Lutz. In May, 1886, the company contracted with Albert Smith to drill a well, and work was immediately begun, the objective horizon being the Trenton limestone which was then yielding such astonishing results in northwestern Ohio. The location was on a lot owned by the president of the company and was situated near the Hocking Valley station. It was soon demonstrated that the territory is covered with a heavy mantle of drift. This retarded the work, and of course increased the expense, so that stockholders were required to pay ten dollars per share more than the face value of their stock. Gas was finally struck February 1, 1887, at a depth of 1,957 feet. On the tenth of the same month the flow was measured at the casing head and found to be 74,880 cubic feet per day. However, the well contained a large quantity of salt

[1] *Lancaster Eagle*, June 21, 1888.



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water, and the pressure of this greatly weakened the flow of gas. Later the well was shot with 100 quarts of nitro-glycerine, and the gas piped to the works of the Hocking Valley Manufacturing Company. The great expense of drilling, and the small production, together with the many other uncertain elements, such as the life of the wells, continuity of the gas rock, etc., made progress slow. That the citizens of Lancaster were not greatly discouraged, however, is shown by the fact that on April 7, 1887, another organization, the Mt. Pleasant Natural Gas and Oil Company was formed. The officers were: President, George W. Welsh; Vice-President, S. H. Beck; Treasurer, H. B. Peters; Secretary, Daniel Danehy. The Board of Directors consisted of the officers and E. L. Slocum, J. T. Busby, H. C. Drinkle, James McSweeny and A. H. Middletown.

About the same time the East End Natural Gas and Oil Company was formed with a capital stock of $5,000.

The second well in the territory was drilled on the land of Joseph C. Kinkead, near the foot of Mt. Pleasant. The gas rock was struck October 5, 1887, at a depth of 1989 feet. Nine days later the flow of gas was measured and found to be 792,000 cubic feet per day, through a four and one-half inch casing. The third well was located about one mile southeast of the city. The gas rock was struck at a depth of 2020 feet, October 11, 1887, and the production is reported to have been 1,000,000 cubic feet in 24 hours.

The companies owning these wells next began to look for a market for their fuel. The most natural one was the city of Lancaster, and on Monday evening, October 23, 1887, the directors of the company owning the well at the foot of Mt. Pleasant asked the city council for a franchise permitting the company to pipe the city. This precipitated a lively debate in which the representatives of the several companies took part. Finally the matter was referred to the committee on streets and alleys, but before a decision could be reached the three companies consolidated, the name being the Lancaster Gas and Oil Company No 1. Officers of this organization were chosen December 5, 1887, as follows: President, P. W. Bininger; Vice-President, C. P. Noll; Treasurer, F. X. Winter; Secretary, W. T. McCleneghan.

On the 18th of the same month the company was authorized to pipe the principal parts of the city. A committee was appointed to visit Findlay and other places where natural gas was in use, the object being to secure information as to the best and safest methods of handling the new fuel. No pains were spared to make the company a success. The result was that within a month after the issuing of permits had begun, there were 500 gas fires in the city. Everybody was calling for gas, making the demand greater than the company could supply, owing to the heavy expense of laying the necessary mains. Fortunately it had been provided when the three companies consolidated that if at any time the city saw fit to purchase

the plant it might do so at actual cost plus six per cent. interest on the investment. To make this possible a law was enacted by the legislature permitting the city to submit to the people a proposition to bond the corporation for $50,000 to purchase the existing natural gas plant, drill new wells, lay mains, etc. The election was held April 30, 1888, the vote resulting 1260 in favor of and 25 against the proposition. Bonds bearing six per cent. interest were at once sold. These were payable from 1892 to 1902, and all found ready buyers. The cost of the plant secured in this manner was about $24,000, the remainder of the money having been used for drilling new wells, laying mains, etc.[1]

During the winter of 1888 and 1889 the supply of gas was not equal to the demand. Thus far all the wells secured were small, while the call for fuel had become very heavy. Under such conditions there was considerable dissatisfaction, and many doubted the wisdom of having bonded the corporation for so large a sum. In fact the future of the field seemed altogether problematical. During this period of doubt and insufficient gas an event occurred which completely changed the aspect of affairs.

This was the great success of the Mithoff well, which was drilled by Theodore Mithoff within the corporation limits, the object being to secure a supply of gas for his machine shop. The gas rock was reached February 17, 1889, and a good flow at once secured.[2] The drill was kept at work and the volume of gas increased rapidly as the rock was penetrated to a greater and greater depth, until the open flow rose to 12,000,000 cubic feet in 24 hours. This was one of the finest gas wells that had ever been drilled up to that time in this or any other county. The citizens of Lancaster were quick to see what this meant for the city, and to properly give vent to their feelings a jollification was planned, with torch light parade, speeches, etc. Arrangements were made to connect this well "The Old Man Himself" with the city mains, thus providing an ample supply of gas.

Another famous well was completed that year. It was located on the county fair grounds, and had an initial open flow of about 10,000,000 cubic feet in 24 hours. A line was laid around the race track that fall, and "By this means the track was lighted up at night as never race track was lighted before, and the trials of speed went forward under this wanton illumination. The idea was novel and the scene unique and brilliant, but the waste was barbaric all the same."[3] Other wells were drilled with varying results; still the quantity of gas at the command of the city was large and the next thing was to find a market for it. "The strange folly that seems bound up in the heart of a municipal corporation when it obtains a good supply of gas, that it must find some one who can use the fuel up in the largest way and most rapidly to whom to give it, without money and without price, broke out also in Lancaster. An ill-omened arch, bearing

1*Ohio Eagle*, Aug. 16 and Sept. 16, 1889. 2*Ibid*, Feb. 21, 1889.
3*Geol. Sur. of Ohio*, First Ann. Rep, 1890, p. 237.

the illuminated inscription 'Free Gas to Manufacturers.' spans the main street of the town at the railroad crossing."[1]

With the increasing demand and the decline in the production of the various wells, the company was obliged to continue drilling. This necessitated leasing additional territory, and since this could be secured only at increasing distances from the city, the expenses of the company have been increasing. By September, 1902, the company had drilled all told about 36 wells, according to data furnished by G. W. Trimble, Superintendent. Of these 18 were producing at that date, 8 had been abandoned and 10 were dry. All of the producing wells, with one exception, are in Berne township. On the authority of the officer just named the company was supplying 10,000,000 cubic feet of gas per day during the coldest weather in the winter of 1901-2, and this did not fully meet the demand. Of this quantity about 20 per cent. went to manufactories, the Columbus Plate Window Glass Company alone using 1,000, 000 cubic feet. In May, 1902, the company was supplying 3,000,000 cubic feet per 24 hours, but only one-third of that was used for domestic purposes. In the following fall (1902) the superintendent estimated that the company could supply from 7,000,000 to 8,000,000 cubic feet per day.

During all the past years no meters have been used, with the result that a tremendous quantity of fuel has been wasted. Rates, adopted March 19, 1889, have been as follows:

Cook Stoves—Domestic.

(For Annual contract service only.)

No. 5 Mixer....$12.00 per annum, payable $1.00 each month
No. 7 Mixer....$18.00 per annum, payable $1.50 each month

Laundry Stove—Domestic.

(Where Cooking Stove is furnished also.)

No. 5 Mixer..... 50c per month

Heating Stoves and Grates—Domestic.

(For continuous service from October 1. to May 1.)

No. 5 Mixer..... $1.00 per month
No. 7 Mixer..... $1.50 per month
For less than seven months' service, higher rates will be charged.

Furnaces and Baltimore Heaters—Domestic.

(Where Heating Stoves and Grates are furnished also.—Continuous service from October 1 to May 1.)

No. 7 Mixer..... $2.00 per month

[1] *Geol. Sur. of Ohio*, First Ann. Rept., 1890, p. 236.

Business Rooms.

No. 5 Mixer..... $2.00 per month
No. 7 Mixer.....$3.00 per month

The rate for ordinary sized rooms used for business offices will be the same as Domestic Heating Stoves.

Hotel and Restaurant Cooking Ranges.

(For annual contract service only.)

No. 5 Mixer..... $1.50 per month
No. 7 Mixer..... 2.00 per month
No. 9 Mixer..... 3.00 per month

The rate for boilers varied from $8 to $60 per month. The window glass company has paid as high as $5,500 for a year of eight months.

The scarcity of the supply and the unfavorable outlook for good territory at last brought the citizens to their senses. In the summer and fall of 1902 meters were introduced, thus putting an end to the untold waste of the last 15 years. The terms are most generous, being ten cents per thousand for domestic purposes and six cents for factories. It is believed that this will greatly diminish the quantity of gas burned, without materially increasing the expense of the consumer, or depriving the poorest of the use of the fuel. Further it will by decreasing the quantity of gas burned, diminish the expense of the company and also prolong the life of the field. The plant has been a good investment for the corporation. It has paid the city debt, the annual payment reaching as high as $35,000. Further, with the exception of $15,000 still due, it has paid for the handsome new city hall costing $83,000. The past year, however, has not been so successful. The receipts have been favorable, but the expense has been heavy. This resulted from the necessity of drilling new wells, several being dry, and the purchase of long strings of pipe. The bonds issued to purchase and extend the plant have all been paid from the gas receipts. In April, 1902, two propositions were submitted to the voters of the town:

1. The issuing of $40,000 worth of bonds for the erection of a municipal natural gas pumping station.

2. The issuing of $20,000 worth of bonds to drill wells, lay pipe, etc.

Both propositions were carried, and the bonds for drilling new wells were quickly sold, but those for the erection of a pumping station found no buyers, owing to doubt as to their legality.

THE NEWARK FIELD.

After the discovery at Findlay, Newark did not long delay drilling for gas. The first well was begun probably in 1885, and was located along the western edge of the town. Progress was very slow; the work was done with pole tools, and besides the 236 feet of drift proved troublesome.

A show of gas was found in the Berea, but the drill was forced through 900 feet of the underlying shales without better results. In October, 1886, a well was begun on the property of the Everett Glass Company. All went well until the drill had descended to a depth of 2,240 feet when a heavy flow of brine was encountered and the driller, unwilling to provide so long a string of casing, abandoned the well. Several members of the company were not willing to give up, however, and a new driller was secured who resumed work, and at a depth of 2,385 feet found a small flow of gas. These tests, while not an unqualified success, proved the existence of a field, and this was enough to insure further exploration.

The third well was soon begun. A flow of perhaps 300,000 cubic feet per day was secured, and this was at once piped to the works of the Everett Glass Company. Other wells were drilled in rapid succession and by 1889 the supply not only met the demands of the glass house, but was sufficently large to warrant piping the city. The wells, however, were all small, the largest probably not exceeding 1,000,000 cubic feet per day; so that the supply in the winter of 1889-90 was not equal to the demand.[1] This stimulated drilling, and during the ensuing 15 years about 24 wells, one-fourth of which were dry, were drilled in the vicinity of Newark. Later the company secured a strip of territory between Newark and Thurston on which a number of producers were secured. At first it was thought that the supply would be equal to all demands, but that was soon found to be a mistake, and its use in factories was discouraged. In the fall of 1901 only two of the wells were still producing, and these were very small. They were drilled in 1891. With the decrease in the local production the city was compelled to look elsewhere for a supply. This was obtained from the Sugar Grove field, the fuel being furnished by the Logan Natural Gas and Fuel Company. On August 19, 1902, The Peoples Natural and Artificial Gas Light and Fuel Company was granted the right to pipe the city. The company's gas territory lies in the Homer field, and it is too early to say at the present time how much of a factor the new company will be in supplying Newark with fuel.

THE THURSTON FIELD.

The discovery of gas at Thurston resulted directly from that at Lancaster and Newark. The place mentioned lies midway between the two cities just named, and it was a very natural thing for the driller to conclude that producing wells might be secured at such a place. The first well was drilled in the spring of 1888 on the Bush farm, near the railroad station, and made just enough gas to encourage the operator to make further exploration. Later a well was drilled about one mile farther east, and it proved to be a large producer. It is reported by J. O. Johnson, Superin-

[1]The foregoing account is merely an abstract from *Dr. Orton's Reports*, Vol. VI, p. 370-1; First Ann. Rept. (1890, p. 237-240).

tendent of the Central Ohio Natural Gas and Fuel Company, to have had a closed pressure of 700 pounds per square inch and an open flow of 7,000,000 cubic feet in 24 hours. It is worthy of mention that these two wells were drilled by Columbus citizens, an organization that later developed into the Central Ohio Natural Gas and Fuel Company.

The success of the second well insured the rapid development of the field, and by the summer of 1889 a sufficient volume of gas had been secured to warrant laying a line to Columbus. The council of that city readily granted a franchise, and in December of the same year a ten inch line had been laid to the city. Early in January, 1890, natural gas was supplied to Columbus for the first time. Unfortunately its use was not restricted to domestic purposes, and by November, 1890, the pressure in the field had so decreased that it was found necessary to discontinue the supply to factories. By January 15, 1891, the fuel was so nearly exhausted that the company was compelled to discontinue supplying Columbus, and from that time very little gas has been piped from the Thurston field.

The territory had a length of three and one-half miles, and a width of one-half mile. The wells near the middle of this territory had an initial production ranging from 5,000,000 to 7,000,000 cubic feet in 24 hours, with a maximum of perhaps 8,000,000. Towards the margin of the belt the wells decreased in size. In the spring of 1902 all but two had been abandoned, and neither of these had been connected with the line for nine years. In fact the pressure in the wells is less than that in the line. The short life of the field resulted from the small area and the heavy demands made upon it. The quantity of gas contained in any field is limited, and the duration of this supply is determined by the demand. Double the latter and the life of the field is cut in two.

THE SUGAR GROVE FIELD.

This is by far the richest part of the Central Ohio natural gas fields, and hence it will be considered more fully than any of the others. Its history has already been touched in the discussion of the development about Lancaster. Perhaps the best procedure will be to consider first the companies that are piping gas from the territory. These are the following:

1. The Lancaster Natural Gas and Oil Company, No. 1.
2. The Central Ohio Natural Gas and Fuel Company.
3. The Ohio Transportation Company.
4. The Logan Natural Gas and Fuel Company.
5. The Ohio Fuel Supply Company.
6. The Northwestern Ohio Gas Company.
7. The Federal Gas and Fuel Company.
8. The Cole Glass Factory, and two or three smaller organizations.

The Central Ohio Natural Gas and Fuel Company.—The first of the companies enumerated above has already been discussed and hence will not be further noticed. The Central Ohio Natural Gas and Fuel Company was incorporated July 1, 1889, with a capital stock of $750,000. The stockholders were principally Columbus citizens, and the object of the organization was to supply that city with natural gas. As has already been narrated the company obtained its first supply from the Thurston field, but the decrease in pressure was so rapid that the company was compelled to practically abandon the territory January 15, 1891. In February of that year the organization completed a well on the Zink farm about two miles north of Lancaster, and was rewarded with a production of 6,000,000 cubic feet of gas per day. Other wells were at once begun and more than a dozen were drilled in that vicinity. This strip runs due east and west across the southern part of Pleasant township. This discovery again filled the lines of the company, and May 1, 1891, Columbus was once more enjoying the finest fuel in the world. From that date the supply has been maintained without interruption. The third step in the development of the company was taken late in 1893, when a well was completed near Sugar Grove. This connected Columbus with the finest reservoir of gas yet found in the state. With the development of the territory around Sugar Grove the company has been able to cut off the wells in Pleasant township. In this manner it is saving that territory. When the Sugar Grove field falls too low to yield an adequate supply the wells in Pleasant township will again be connected with the company's lines. The rock pressure in this part of the field was originally 700 pounds. At present (1902) it ranges from 500 to 600 pounds. In 1901 the company began work in the Homer field, and by September of that year had completed 13 wells, one only of which was dry. A line was laid to Columbus in the fall of 1902, and the use of gas from the new field at once begun.

In the fall of 1900 the company erected a pumping station at a point between Lancaster and Sugar Grove, the pressure of the field having fallen so low that it was no longer able to supply a city so far distant as Columbus. The power consists of four engines connected tandem fashion, the combined horse power being 1,000. A pressure of from 60 to 325 pounds is maintained in the line. The latter has a diameter of 12 inches from Columbus to Canal Winchester, and of 10 inches from the last place to the pump station.

The total number of wells drilled by this company to September, 1902, was about 110.

The price of natural gas in Columbus was fixed by act of the city council December 17, 1888. This was before the Columbus Natural Gas and Fuel Company was granted a franchise to pipe the city. The rates established were as follows:

For Cooking.

From November 1 to May 1.	Monthly Charges	If paid before the 10th: Discount	If paid before the 10th: Net Ch'ges	From May 1 to November 1.	Monthly Charges	If paid before the 10th: Discount	If paid before the 10th: Net Ch'ges
No. 7 Mixer...	$2.78	.28	$2.50	No. 7 Mixer...	$1.66	.16	$1.50
No. 5 Mixer...	2.22	.22	2.00	No. 5 Mixer...	1.39	.14	1.25
No. 3 Mixer...	1.67	.17	1.50	No. 3 Mixer...	.83	.08	.75

For Large Cooking Range.

No. 9 Mixer...	$3.33	.33	$3.00	No. 9 Mixer...	$2.22	.22	$2.00

For Laundry.

When gas is furnished for cook stove also.

	Monthly Charges	Discount	Net Charges		Monthly Charges	Discount	Net Charges
No. 7 Mixer...	$1.11	.11	$1.00	No. 5 Mixer...	$0.83	.08	$0.75

Manufacturer's rates for fuel shall be 75 per cent. of the cost of coal and no more.

For Heating.

No. 7 Mixer.

	Monthly Charges	If paid before the 10th: Discount	If paid before the 10th: Net Ch'ges		Annual Charges	If paid before the 10th: Discount	If paid before the 10th: Net Ch'ges
1st Mixer.....	$5.00	.50	$4.50	1st Mixer..	$30.00	$3.00	$27.00
2d Mixer.....	4.44	.44	4.00	2d Mixer..	26.44	2.64	24.00
3d Mixer.....	3.89	.39	3.50	3d Mixer..	23.34	2.34	21.00
4th Mixer.....	3.33	.33	3.00	4th Mixer..	19.98	1.98	18.00
5th Mixer.....	2.78	.28	2.50	5th Mixer..	16.68	1.68	15.00
6th Mixer.....	2.22	.22	2.00	6th Mixer..	13.32	1.32	12.00

No. 5 Mixer.

1st Mixer.....	$3.89	.39	$3.50	1st Mixer..	$23.34	$2.34	$21.00
2d Mixer.....	3.33	.33	3.00	2d Mixer..	19.98	1.98	18.00
3d Mixer.....	2.78	.28	2.50	3d Mixer..	16.68	1.68	15.00
4th Mixer.....	2.22	.22	2.00	4th Mixer..	13.32	1.32	12.00
5th Mixer.....	1.66	.16	1.50	5th Mixer..	9.96	.96	9.00
6th Mixer.....	1.39	.14	1.25	6th Mixer..	8.34	.84	7.50

No. 3 Mixer.
For heating small rooms and for special purposes.

	Monthly Charges	If paid before the the 10th: Discount	If paid before the the 10th: Net Charges
1st Mixer	$2.22	.22	$2.00
2d Mixer	1.66	.16	1.50

Furnaces.

	Monthly Charges	If paid before the 10th		Annual Contracts		
		Discount	Net Ch'ges	Annual Charges	Discount	Net Ch'ges
"A" Mixer, 21-inch fire pot..	$6.95	$0.70	$6.25	$41.70	$4.20	$37.50
"B" Mixer, 24-inch fire pot..	8.66	.86	7.80	51.96	5.16	46.80
"C" Mixer, 26-inch fire pot..	9.44	.94	8.50	56.64	5.64	51.00
"D" Mixer, 28-inch fire pot..	10.00	1.00	9.00	60.00	6.00	54.00
"E" Mixer, 30-inch fire pot..	11.66	1.16	10.50	69.96	6.96	63.00
"F" Mixer, 35-inch fire pot..	13.89	1.39	12.50	83.34	8.34	75.00

July 29, 1889, the city council amended its previous act fixing the rates for natural gas in Columbus by providing that if the company or companies adopt the meter system they shall charge twelve and one-half cents per thousand cubic feet, and for the meter $3.00 per year. This act like the previous one was to stand ten years. When the company shut down its plant January 15, 1891, only a small number of meters were in use, and these were looked upon as experiments. This act also gave the consent of the city to the transfer from the Columbus Natural Gas and Fuel Company of its privileges secured under the act of July 29, 1889, to the Central Ohio Natural Gas and Fuel Company. The first named organization, while the pioneer in the field, seems to have done little more than secure the franchise. On March 30, 1891, the city council repealed these two ordinances and established a meter rate. This simply fixed the price of gas at twenty-five cents per thousand cubic feet, and of the meter at $3.00 per year. The term was for ten years and no further change in price was made until the close of that period.

The next and last change in the price of natural gas was made July 1, 1901. This fixed the rate for a period of ten years. The ordinance is given below:

AN ORDINANCE, No. 18,338, To fix the price to be charged by natural gas companies for gas in the city of Columbus, Ohio, for the period of ten years.

Be it ordained by the City Council of the city of Columbus, Ohio, as follows, to-wit:

SECTION 1. That any natural gas company or companies which now have the right to lay and maintain pipes and mains in the streets, avenues, alleys and public grounds of said city for the purpose of carrying and distributing natural gas for private and public use in said city, shall, for the period of ten years from and after passage of this ordinance, be entitled to charge for such gas furnished to public and private consumers thereof, the sum of thirty-five cents per thousand cubic feet, from which price a discount shall be made upon all bills paid on or before the 10th day of each month for gas consumed during the preceding month at the rate of 15 cents per thousand cubic feet during the first and second years, and at the rate of 10 cents per thousand cubic feet during the third and fourth years, and at the rate of 5 cents per thousand cubic feet during the fifth, sixth, seventh, eighth, ninth and tenth years from and after the passage of this ordinance.

SEC. 2. That if any such company or companies shall be unable at any time within ten years from the passage of this ordinance to so continue to furnish natural gas for fuel by reason of insufficient quantity to supply the demand thereof, and shall devise or construct a system or means for furnishing fuel gas, such company or companies shall be entitled, during a period of ten years from the passage of this ordinance, to charge for all such fuel gas furnished for fuel purposes, a sum not to exceed 60 cents per thousand cubic feet, from which price a discount of 10 cents per thousand cubic feet shall be made upon all bills paid on or before the 10th day of each month for gas furnished during the preceding month. Provided, however, that if there should be a difference of opinion between said city council and the company so furnishing natural gas as to whether such company at any time within ten years from the passage of this ordinance is unable to continue to furnish natural gas, by reason of insufficient quantity to supply the demand therefor, the question of whether there is a sufficient quantity shall be determined by arbitrators, one to be selected by said City Council and one by such company, which two shall select a third arbitrator, and the action and award of a majority of such arbitrators as to there being such sufficient quantity, shall be final and binding on all parties.

SEC. 3. When said gas company or companies shall file with the city clerk its or their assent in writing to the terms of this ordinance, the said ordinance and acceptance shall be treated and deemed as a compliance with law for the company or companies so accepting, provided nothing shall be construed as granting to existing companies exclusive rights or privileges, or prevent any other natural gas company or companies from furnishing natural gas to the citizens of said city.

SEC. 4. That said company or companies by accepting the terms of this ordinance shall consent and agree not to sell natural gas or furnish to be sold to any other city or town, or supply the same with gas except those now being supplied by the companies now furnishing gas in the city of Columbus, until all demands for gas in the city of Columbus are supplied, at the prices herein provided even though a higher price may be offered for said gas by some other city or town; and said company or companies shall be permitted to sell to other cities or towns only such gas as it or they may have in excess of that which is demanded for the city of Columbus.

SEC. 5. This ordinance shall take effect and be in force upon its passage and publication according to law.

Passed July 1, 1901.

JAMES J. THOMAS,
President of the City Council.

Approved by the mayor, July 6, 1901.
Attest: JOHN T. BARR, City Clerk.

When the company first began supplying Columbus with gas, about January 1, 1890, it furnished the fuel to factories as well as to residences. By the following November the pressure in the field had so diminished that it was necessary to disconnect the factories, and so base a use of the fuel has not since been made except during the summers of 1899 and 1900. This has greatly prolonged the supply, for which the citizens of Columbus are indebted to the management of the company. In the autumn of 1902 the lines were supplying about 66,000 fires. Mr. J. O. Johnson, superinten-

dent of the company, estimates that during the past five years his corporation has taken on the average 6,500,000 cubic feet of gas per day from the territory.

The Ohio Fuel Supply Company.—The Great Southern Oil and Gas Company entered the Sugar Grove field in 1897, its purpose being to supply Zanesville and intermediate points with gaseous fuel. It is popularly known as the Zanesville company. On May 1, 1902, the corporation transferred its entire property to the Ohio Fuel Supply Company. Besides Zanesville the following places are supplied—Bremen, Rushville, Somerset, Roseville and Crooksville. It is scarcely necessary to state that by far the greater portion of gas is consumed in Zanesville where the following factories are supplied:

National Biscuit Company, gas for heating ovens;
Schultz & Company (Soap works), gas for boilers;
Zanesville Art Pottery Company, gas for kilns and boilers;
S. A. Weller, Pottery, gas for kilns and boilers;
L. K. Brown, Brick and Clay Works, gas for gas engine;
Roseville Pottery Company, gas for kilns and boilers;
Eastern Tube Company, gas for furnaces;
Faience Pottery Company, gas for kilns and boilers;
Zanesville Stoneware Company, gas for kilns and boilers;
Mosaic Tile Company, gas for kilns and boilers;
Ohio Pottery Company, gas for kilns and boilers;
J. B. Owens, gas for kilns and boilers;
G. W. Karns, gas for glass making;
Muskingum Valley Steel Company, gas for boilers and furnaces;
American Encaustic Tile Company, gas for kilns and boilers;
Brown Manufacturing Company, gas for welding and general purposes;
American Chain Company, gas for furnaces and boilers;
Kearns Gorsuch Glass Company, gas used throughout plant;
C. W. Stine Pottery Company, gas throughout plant.

In addition to these establishments the company supplies gas to a large number of residences, offices, stores, etc. In the summer and fall of 1902 the company laid an eight inch line to the Homer field and began using gas from that territory November 19th. The net rates reported are 20 cents per thousand cubic feet for domestic purposes and 12 cents for factories.

Before connection was made with the Homer field the company was not able to supply fully all the factories named, and it is very doubtful if the new field will long provide an ample quantity. In the territory around Sugar Grove the company had 17 producing wells in September, 1902. Early in the year just named the organization constructed a pump-

ing station, and since that time powerful compressors have assisted in keeping the line well filled. The power is furnished by two engines, each of 500 horse power. A pressure of from 150 to 180 pounds per square inch is kept on the line.

The Logan Natural Gas and Fuel Company.—This company was organized with a capital stock of $40,000 in 1894. The first line was laid to Logan, and in fact the original object of the company was to supply that town only. Finding the supply of fuel larger than the demand a line was laid to the Boys Industrial School, and later this was extended to Laurelville, Adelphi and Chillicothe. The corporation's business has grown rapidly, and by 1903 it was supplying the following places in addition to those already mentioned; Nelsonville, Athens, Newark, Mt. Vernon, Utica, Granville, Thornville, Millersport, Westerville, Cardington, Delaware, Ashland, Bucyrus, Upper Sandusky, Carey, Fostoria, Tiffin, Mt. Gilead, Marion, Galion, Crestline, Mansfield, Shelby, Chicago Junction, Norwalk, Bellevue and Clyde. Quite recently it has secured some sort of control over the Buckeye Company which supplies Circleville. In addition to all this territory the company is endeavoring to extend its lines, and by the time this article is in type the list of cities will in all probability be extended.

The first well drilled by the Logan Natural Gas and Fuel Company was completed in June, 1894. Four years later the property passed into the hands of an organization headed by T. N. Barnsdale. At that time the company had only six producing wells. In September, 1902, the number had grown to 80, exclusive of those in the Homer field. The estimated average open flow of these was 500,000 cubic feet per day. The Buckeye Company, which, as has already been stated, is under the control of the Logan, has drilled 16 wells, all of which were still producing in September 1902. With the decrease in the rock pressure the company has found it necessary to resort to artificial pressure, and accordingly in 1902 erected a pumping station. The power consists of one 600 horsepower Westinghouse engine and one 450 horse-power Kline engine. Each engine operates two compressors, one set having dimensions of 11½ x 36 inches, and the other 14 x 36. The cost of the plant was estimated at about $125,000. The company is making every effort to maintain its supply of fuel and for this purpose keeps several strings of tools at work. When gas was discovered in the Homer field, attention was directed that way, with the result that by September, 1902, the company had 20 wells completed and nine drilling.

The Ohio Transportation Company.—This is a popular name for an organization whose title is the Central Contract and Finance Company. It is also frequently called the Springfield Company. The corporation entered the Sugar Grove field in 1897, laying a 10 inch line to Springfield, a distance of over 80 miles. During some years previous to the date

just mentioned The Miami Valley Gas and Fuel Company had supplied Dayton, Springfield and other places with fuel from the Mercer county field. When this territory failed the company connected its lines with that of the Ohio Fuel Supply Company. In this manner the latter organization has been able to dispose of its gas by simply laying a line to Springfield. The cities and towns in this part of the State supplied with gas from the Sugar Grove field are the following; Dayton, Springfield, Urbana, Piqua, Troy, Sidney, Mt. Sterling, and several small intermediate places. By the spring of 1900 the closed pressure of the wells had so decreased that it was necessary to resort to artificial pressure, and accordingly a pumping station was constructed. The power is furnished by five engines, each of 250 horse power. In 1902 a second pumping station was constructed at Mt. Sterling nearly midway between Sugar Grove and Springfield. The average pressure reported on the line is 250 pounds per square inch. On September 1, 1902, the company had 52 producing wells. The average open flow of these on March 1st preceding was 1,087,000 cubic feet in 24 hours, and an estimated average daily production of 850,000 cubic feet six months later. Of the latter it was thought that only 250,000 cubic feet were available. During the summer of 1902 about 15,000,000 cubic feet of gas were pumped daily from the territory by this company, and it was thought that the quantity would not change materially during the ensuing winter. In cold weather the principal use made of the gas is for domestic purposes, but in summer months a number of factories are supplied. In this manner the shipment of fuel is kept fairly constant. The supply is maintained only by drilling new wells and using powerful compressors. On September 1, 1902, the company had drilled all told about 90 wells, of these perhaps 20 had been abandoned, and approximately 13 were dry when drilled.

The Northwestern Ohio Gas Company.—This corporation is unique in that it operates no wells, purchasing its gas directly from another company or companies. It has a ten inch line running directly to Toledo, a distance of 161 miles. In September, 1901, the company began constructing and soon had in operation two gas engines each of 1,000 horse power, and a year later erected a third engine of similar character and strength. These suffice to keep a pressure ranging from 125 to 200 pounds on the line. This company is said to be the property of The Standard Oil Company, and that the line will be connected with the great 16 inch one now being laid from West Virginia to Sugar Grove. In the fall of 1902 the company was pumping an average of perhaps 8,000,000 cubic feet of gas per day.

The Federal Gas and Fuel Company.—This company was incorporated in 1898. Through action of the legislature, it secured control for gas purposes, of the canal between Lancaster and a point about two miles south of Rock Bridge, Hocking county. This extended through

the heart of the Sugar Grove field, but the territory adjacent to the canal had in the main seen several years use before the Federal company was organized.

The company desired Columbus as a market for its fuel, but naturally the Central Ohio Natural Gas and Fuel Company opposed this. The result was a strong fight in the council at Columbus over a proposition giving the Federal Gas and Fuel Company the right to pipe the streets. However the company won, but only on the condition that it supply fuel at not more than 15 cents per thousand cubic feet. A twelve inch line was laid to the city, and consequently many citizens were supplied who before had been unable to secure natural gas. The company supplies Canal Winchester and Logan also, the rate being 20 cents per thousand.

By November, 1902, this company had drilled over 30 wells. Of these 20 were producing at that time, and a half dozen had been abanddoned. The others were failures. Fifteen of the 20 producers just referred to were located in the old canal bed. The others were in Good Hope and Berne townships where the company had secured leases. Additional wells were being drilled, and doubtless the number of producers is now correspondingly larger. Since the wells of this company have been drilled in territory from which a large part of the gas had previously been taken, it follows that the life of the wells will be brief. No pumping station has yet been erected. In April, 1903, the property of this company passed into the hands of the Ohio Fuel Supply Company.

The Cole Glass Factory and Other Companies Using Gas.—The first named organization located at Lancaster has drilled ten wells, six of which are producers. The average daily consumption of gas by this factory when running, as reported by Mr. C. P. Cole, is 1,000,000 cubic feet. All wells are located in Berne township.

The Ohio Flint Glass Factory, also situated in Lancaster, has drilled six wells, all in Berne township. Five of the number were producers, but one of these has been abandoned. The superintendent of the plant, Mr. L. P. Martin, reports that it consumes when in operation about 1,000,000 cubic feet of gas per 24 hours. Besides the two factories just named there are two or three others which have in part an independent supply.

THE HOMER FIELD.

The first well in the Homer field was drilled in July, 1900, and is reported to have begun producing 1,000,000 cubic feet of gas per day. Other wells were soon drilled with similar results. Later, better producers were secured, and in 1902 development was very active. Few dry holes were drilled, and the production started ordinarily at from 1,000,000 to 4,000,000 cubic feet per well; the closed or rock pressure varying from 700 to 800 pounds per square inch.

Early in the fall of 1902 a well was completed on the Hunter farm near the middle of section 6 of Miller township, Knox county. According to reliable reports this had an initial open flow of between 11,000,000 and 12,000,000 cubic feet per day. In December following a well was completed on the Miller farm located in the northern part of the same section, and a 9,000,000 cubic foot producer secured. Early in January, 1903, a well was drilled on the Beinhower farm in the southwest corner of the same section, the result being an open flow at the rate of 11,000,000 cubic feet per 24 hours.[1] While these wells were being drilled a number of producers ranging in size from 4,000,000 to 6,000,000 cubic feet were secured farther north. This is by far the richest portion of the Homer field, and radically changes the character of the territory.

It appears from what has just been stated that the size of the maximum wells in this field equals those of Sugar Grove; the average of those of Homer, however, is much smaller. Time has not been sufficient to test the lasting quality of the wells in the new field, but the indications are that it will compare favorably with the excellent territory farther south.

Strenuous efforts are being made to extend the limits of the producing territory. A small well has been secured in the northwest corner of Clay township, Knox county, and one on the Taylor farm in the northern part of Union township, Licking county. The latter well, according to information furnished by Professor Thomas L. Watson, had an initial open flow of 2,000,000 cubic feet per day, and a closed or rock pressure of 800 pounds per square inch. Both wells lie outside of what is known as the Homer field.

Several of the largest companies operating in the Sugar Grove field have entered this territory, and are piping gas to Columbus, Zanesville and other places. Doubtless in the near future fuel from the Homer field will be consumed in many cities in northern Ohio. This much can be said for the territory at present,—the acreage is large, rock pressure high, and gas rock continuous.

GEOLOGY OF THE FIELD.

Succession of Strata.—This is shown by the following records: Well No. 1 of the Federal Gas and Fuel Company, located in the canal bed four miles below Lancaster. Completed April 28, 1899.

Character of Formation.	Thickness of formation. Feet.	Depth to bottom of formation. Feet.
Drive pipe	54	54
Shale	91	145
White sand, charged with water	20	165
Sandy shale	135	300
Gray shale	90	390

[1]Data furnished by J. O. Johnson, Supt. Central Ohio Nat. Gas and Fuel Co.

Character of Formation.	Thickness of formation. Feet.	Depth to bottom of formation. Feet.
Sunbury (Berea) shale	52	442
Berea sand	25	467
Cased with 8¼ inch casing.		
Red shale (Bedford)	103	570
Black shale (Ohio)	560	1,130
White shale (Ohio)	142	1,272
Top of lime (Corniferous) at	...	1,272
First water in lime at	...	1,407
Second water; rose to top of well	...	1,682
Cased with 6⅝ inch at	...	1,944
Bottom of Niagara limestone at	...	1,959
White slate	66	2,025
Red rock (shales)	18	2,043
Limestone shell	8	2,051
Blue slate	4	2,055
Shells	15	2,070
Blue slate	5	2,075
Clinton sand, top	...	2,075
Total depth	...	2,088

Below is given a record of the lower part of the Bauer well located on section 5 of Berne township. Samples of the drillings were collected by the writer.

	Feet.
Bottom of the Niagara limestone at	2,132
Shales, light chocolate color; some lime	2,132–2,168
Shales, green and chocolate colored, the latter fossiliferous; some lime	2,168-2,199
Shales, green and chocolate colored; much lime.	2,199-2,236
Clinton sand at	2,236

For comparison there is given next the record of the deep well drilled on the Kockensberger farm about 20 miles east of Lancaster, near Junction City. This well was begun in March, 1900, and completed two years later:

	Character of Formation.	Thickness of formation. Feet.	Depth to bottom of formation. Feet.
Waverly...	Drift	15	15
	Blue clay, top at	15	30
	White sand	75	105
	40 ft. 8¼ in. casing.		
	Blue slate	15	120
	Gray sand	20	140
	White sand	30	170
	Slate and shells	50	220
	Black shale	30	250
	White slate (Cuyahoga)	300	550
	Brown slate (Cuyahoga)	235	785
	Sunbury (Berea) shale	41	826
	Berea sand (steel line measurement)	14	886
	White slate and red rock	14	900
	910 ft. of 6⅝ in. casing.		

	Character of Formation.	Thickness of formation. Feet.	Depth to bottom of formation. Feet.
Ohio shales.....	Black slate	60	960
	White slate	355	1,315
	Brown slate	295	1,610
	White slate	110	1,720
	Brown slate	15	1,735
	White slate	165	1,900
	Slate	160	2,060
Corniferous, Lower Helderberg and Niagara	Top of Corniferous limestone at.....	....	2,060
	Break in limestone at..	....	2,500
	Bottom of break at.....	....	2,560
	Bottom of limestone at..	....	2,950
	2,810 feet of 5 3-16 inch casing.		
Clinton.....	Red rock	40	2,990
	Blue slate	95	3,085
	Clinton sand stone at.....	....	3,085
	Bottom of well, still in Clinton	....	3,100

The most interesting point about this section relates to the Ohio shales. These were struck at a depth of 900 feet, and the bottom was reached at 2,060 feet, showing a thickness of 1,160 feet for the formation. The record of the Federal well near Lancaster gives these shales a thickness of 702 feet. This is an increase of 458 feet in about 20 miles, or 23 feet to the mile. The great limestones have a thickness in the Federal well of 687 feet, and this is about the average for the entire Sugar Grove field. In the Junction City well the thickness found is 890 feet, an increase of 203 feet or about ten to the mile. The deep well drilled at McConnellsville found the Ohio shales 1,712 feet thick.[1] This point is 42 miles east of the Federal well; hence the increase in thickness of the Ohio shales averages 24 feet to the mile. If this rate of increase continues eastward to the Ohio river the formation would reach 3,000 feet in thickness. This corresponds with what has already been demonstrated in Columbiana county. The importance of this feature in our geology cannot be over-estimated by the seeker for oil or gas. It demonstrates the folly of attempting to make the Clinton or Trenton formation a source of oil or gas in a commercial way in eastern Ohio.

The following skeleton record of the McNichols well, twenty-five miles south of Sugar Grove in Jackson township, Vinton county, is of interest because it shows the thickness of both the Clinton and the Medina:

[1]It will be noted that these figures do not agree with those given on the accompanying diagram. The difference results from the Ohio shales alone being considered in the text, while in the diagram both the Bedford and Ohio shales are included.

	Feet.
Berea grit, top at	888
bottom at	942
730 feet of 8 1-3 inch casing.	
942 feet of 6¼ inch casing.	
Corniferous Lower Helderberg and Niagara limestones, top at	1,735
bottom at	2,390
Clinton, top at	2,390
bottom at	2,460
Medina, hard above, but very soft below, top at	2,460
bottom at	2,560
2,554 feet of 5 3-16 inch casing.	
Cincinnati series, top at	2,560
bottom of well	2,860

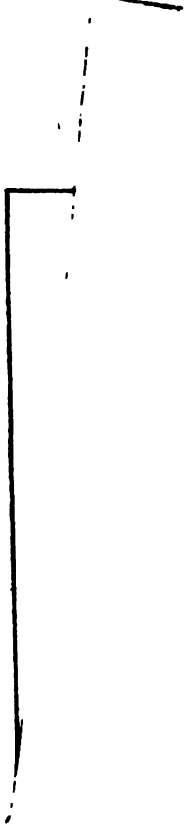
Lastly there is given a skeleton record of a well near Homer, in the northern part of the Central Ohio Natural Gas Fields. The location is on the Beatty farm in Burlington township, Licking county:

	Feet.
Drive pipe	160
Bottom of Berea (cased here)	618
Top of limestone (Corniferous)	1,420
Bottom of limestone (Niagara)	2,100
Top of Clinton sand	2,303
Bottom of Clinton sand	2,315
Top of Medina shales	2,340
Total depth	2,345

This makes the interval between the Berea grit and the Ohio shales 802 feet, and the thickness of the limestone 680 feet. Other wells drilled in different parts of the field make the interval referred to vary from 754 to 826 feet, and the thickness of the limestone range from 680 to 764 feet. An average of 7 measurements gives 743 feet. This is nearly 50 feet greater than the average in the Sugar Grove field.

The Clinton Formation.—The only part of Ohio in which the Clinton outcrops is the southwestern. Its area there is very small, but it is usually conspicuous. This results from the fact that the underlying rocks are shales; while the Clinton, being composed of much more durable material, forms an escarpment. The formation is composed essentially of limestone. This is highly crystalline, delicately colored, and quite fossiliferous. It takes a good polish and has been called marble. At places it is a building stone of high grade, but the lenticular nature of the bedding is an obstacle to its use for this purpose. In composition the limestone is calcareous, and in places it becomes the purest rock of this type in Ohio. The following is an analysis from near Osborn, Green county:[1]

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 728.



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	Per cent.
Carbonate of lime	97.14
Carbonate of magnesia	1.21
Alumina and oxide of iron	.41
Silicious matter	.70
	99.46

Occasionally there is found a thin bed of clay, called by Foerste the Beavertown marl, overlying the limestone, and at other places a lean deposit of the Clinton ore. The latter furnished the iron for one of the pioneer blast furnaces of the state.

That the Clinton limestone along its line of outcrop contains petroleum has long been known. This character appears to have been reported for the first time by Dr. John Locke in 1838.[1] Orton made similar observations in 1878, 1886[2] and 1888.[3] Neither of these geologists, however, suspected from the surface exposure that the formation might contain either oil or gas in quantities sufficiently large to be of service to man. When the Trenton was being tested at Fremont it was noticed that considerable gas escaped from the Clinton, and the former horizon proving barren a number of wells were drilled to the latter, the supply of gas secured being sufficient usually for one or more residences.[4] These were the first wells drilled anywhere in Ohio for the purpose of securing gas from the Clinton. The formation in the northwestern part of the state consists of limestone with a small amount of shale. The general relations are shown in the following record of a well at Fremont:[5]

	Feet.
Waterlime	160
Niagara limestone	200
Niagara shale (thin)	
Clinton limestone	105
Medina shale	105
Cincinnati (Hudson River) shale	450
Utica shale	308
Trenton limestone at	1,328

In central Ohio the formation presents a complete change. The limestone has disappeared and there is found in its place a body of shales and generally an intercalated bed of sandstone. As shown in the well records already given these shales have colors ranging from green to brown. They contain a noticeable amount of carbonate of lime which becomes most abundant in the 35 feet above the gas rock. The drillings strongly indicate that the green and chocolate colored shales are inter-

[1] *Geol. Sur. of Ohio*, Sec. An. Rept. (1838), p. 225.
[2] *Ibid*, Preliminary Rept. on Oil and Gas (1886).
[3] *Ibid*, Vol. VI, p. 12.
[4] *Ibid*, Vol. VI, p. 187-8.
[5] *Ibid*, Vol. VI, p. 112.

stratified with the calcareous ones. The gas rock is a light colored sandstone of moderate fineness. In the northern part of the territory the rock has less color and also fewer impurities than it has in the Sugar Grove field—if the testimony of experienced drillers can be relied upon. Farther south in Vinton county the sand has a decided brown color. The rock drills hard, suggesting that the grains of sand are well cemented together. It has not been customary around Sugar Grove to drill through the gas rock, and hence data bearing on its thickness are not abundant. The maximum reported is 34 feet, and the average is perhaps a little more than one-half of that. In the northern part of the field, that is around Homer, the sand is drilled through. Five wells selected at random show thicknesses of 10, 28, 8, 12 and 18 feet, an average of 15.

Below the gas sand is found a bed of shales commonly ranging from 10 to 35 feet in thickness. This has a dark color, and is succeeded below by red shales. Since work usually stops before the latter are reached, or when they have been penetrated a few feet, thus making certain that the position of the gas sand has been passed, data bearing on the thickness of these shales are meager. The McNichols well, a log of which has already been given, credits 100 feet to the formation. The top of this red rock is regarded as the summit of the Medina.

Rock Structure.—The strata in the Sugar Grove field have been considered by some on *a priori* grounds to form an anticline, and by others a terrace. Neither, however, appears to be correct. On a line running about due east and west through Sugar Grove, the rock dips to the east nearly 260 feet in less than six miles, barometer measurement, an average of 45 feet per mile. This shows neither arch nor terrace extending through the territory north and south. Further at the village Amanda, 11 miles west of Sugar Grove, the Clinton rock lies 600 feet higher than it does at the village last named. This makes improbable the suggestion that the gas belt may lie on the eastern slope of an arch, as several reservoirs of oil and gas are known to do in eastern Ohio.

From Lancaster the rock dips southeast more rapidly than the bed of the Hocking river slopes, as is shown by the increasing depths of the wells in the valley of this stream. This excludes the idea of an east and west arch or terrace.

Size of the Wells.—The closed or rock pressure in the Sugar Grove field was originally about 700 pounds per square inch. At present it varies much. Thus at Lancaster, where the first wells were drilled, the pressure has fallen so low that with one exception all wells have been abandoned, while a mile or two farther north in the southern part of Pleasant township the pressure is still from 500 to 600 pounds. Near Sugar Grove the pressure (September 1, 1902) was less than 200 pounds, in some wells only one-half of that, but farther away from the village it is greater. Thus a well drilled in the fall of 1902 on the Brandon farm,

five miles north of Sugar Grove, showed a rock pressure of 400 pounds, and one on section 2 of Laurel township, Hocking county, drilled in December, 1901, recorded 700 pounds and nine months later 650 pounds per square inch. These variations indicate that the field does not consist of one vast reservoir, but of several small disconnected areas. These are separated either by the sandstone disappearing or more probably by the rock becoming so compact in places that it cannot act as a reservoir for the gas.

The open flow of the wells has varied greatly. Thus wells early drilled in the vicinity of Lancaster have ranged from almost nothing to 12,000,000 cubic feet per day. Among the largest reported are the following: One in Laurel township, Hocking county, 9,500,000 cubic feet; one on the Hummel tract in Berne township, Fairfield county, 10,000,000 cubic feet; the Mithoff well in Lancaster, 12,000,000 cubic feet. These figures, of course, refer to the initial open flow.

As has already been stated the initial closed pressure in the Homer field ranged from 700 to 800 pounds per square inch, and the open from 1,000,000 or less to more than 11,000,000 cubic feet in 24 hours. Data concerning the wells in the Newark and Thurston fields have already been given, and it is seen that the initial closed or rock pressure of the entire central Ohio fields has ranged from 700 to 800 pounds per square inch, and that the largest well had an open flow approximating 12,000,000 cubic feet per day. A number of experiments have been made by torpedoing the wells, but the results have not been satisfactory.

Life of Wells.—This depends on several factors; such as nature of gas rock, closed pressure, initial flow, proximity of other wells, rapidity with which gas is used, care taken of wells, presence or absence of salt water in the gas rock, etc. A small number of wells drilled ten years ago are still producing, but such records are unusual. The short life of the Thurston field has already been noted. The Homer field is too young to have demonstrated its lasting qualities. The following records in the Sugar Grove field show the decline in rock pressure and open flow of the wells in that territory. These are wells that have been in almost continuous use. Of course where the wells are closed in during a large part of the year the decrease is much slower than the records previously given indicate. This point is well illustrated in the wells north of Lancaster, which were drilled about ten years ago, but still have a closed pressure of from 500 to 600 pounds per square inch. As has already been stated the company is holding them in reserve until the wells in other parts of the field are inadequate to meet the demands. The table shows very clearly the brief life of the wells. Since the rock pressure is decreasing it follows that wells drilled hereafter will be exhausted even more rapidly than those given below.

Table Showing the Initial Rock Pressure and Open Flow, and the Decrease of these in Wells of the Sugar Grove Field.

Name of Well.		Rock pressure, pounds per square inch.	Open flow per 24 hours, cubic feet.	Rock pressure, April 1, 1901.	Open flow, April 1, 1901.	Rock pressure, Sept. 1, 1902.	Thickness of sand, feet.	When abandoned.
Berry No. 1	Oct , 1897	785	7,161,000	..0	0	..0	18+	July, 1899.
Conrad No. 1....	Oct., 1897	900	4,570,350	190	2,260,000	..0	14+	Nov. 18, 1901.
Blazer No. 1.....	Oct., 1897	740	9,000,000	170	3,500,000	..0	...?	Feb. 4, 1902.
Berry No. 2.....	Nov., 1897	740	7,151,500	150	1,746,000	..0	13+	June 5, 1901.
Lutz No. 1.....	Nov., 1897	890	3,212,500	230	2,254,300	170	...?	Still prod. Sept., 1902.
Kestler No. 2....	Nov., 1899	500	8,758,000	240	....?	120	15+	" " " "
Ream No. 1	Apr., 1898	790	7,163,000	205	3,162,800	125	7+	" " " "
Harman No. 1...	Jan., 1899	650	9,969,000	220	.. ..?	..?	...?	" " " "
Wooden No. 1. .	Sept., 1898	700	8,374,000	..0	0	..0	18+	Abandoned Feb., 1901.
Shull No. 1.....	July, 1899	640	8,870,500	300	5,530,000	150	18+	Still prod. Sept., 1902.
Edwards No. 4...	Feb., 1900	410	3,000,000	230	.....?	175	20+	" " " "
Kesler No. 1.....	Dec., 1897	800	6,451,000	225	3,571,800	100	13+	" " " "
Starner No. 1....	July, 1901	420	7,500,000	..?	.....?	120	24	" " " "
Brandan No. 1...	July, 1901	425	2,000,000	..?	.....?	250	19	" " " "
Dupler No. 1	Nov., 1901	580	7,128,000	..?	.....?	210	26	" " " "

Care of Wells.—Care is required with reference to two points; (1) water, (2) salt, the former being by far the most troublesome. Both are derived from the great limestone lying above the Clinton formation, and if it were possible to prevent the salt-water from reaching the gas sand no trouble would be experienced from either.

When the closed pressure is large the water is driven from the gas rock by simply opening the well at the top, and allowing the gas to drive the water from the well; but when the pressure has become small, as it will be in all cases sooner or later, the force of the gas may not be sufficient to lift a column of water filling a two inch tube. In such cases an inch tube is inserted inside the two inch, and the pressure of the field turned into the large one, thus forcing the water through the smaller tube.

The frequency with which wells require blowing varies with the nature of the well. Some require attention twice a day; others twice a a week; others once a week, etc. The time required to clean the well varies greatly, increasing with the quantity of water to be removed and the decrease of the rock pressure. Perhaps the average time in the Sugar Grove field in 1902 was 15 or 20 minutes.

Trouble from salt arises in one of two ways, either by accumulating in the gas rock, or around the end of the tubing, and so shutting off the flow of gas. This is removed by first pouring water into the well, and thus dissolving the salt, and then blowing the brine out by the method already explained. In obstinate cases vinegar is used in place of water.

Composition of the Gas.—Below is given an analysis of gas from the Thurston field, the work having been done by Professor C. C. Howard of Starling Medical College:

	Per cent.
Carbon dioxide	.25
Oxygen	.15
Olefines	.30
Carbon monoxide	.15
Nitrogen	8.12
Hydrogen	.55
Paraffines (Marsh gas, etc.)	90.48

For comparison there is given an analysis, made by the same chemist, of natural gas from the Trenton limestone at Findlay.

	Per cent.
Marsh gas	92.61
Olefiant gas	.30
Hydrogen	2.18
Nitrogen	3.61
Oxygen	.34
Carbonic acid	.26
Carbonic oxide	.50
Sulphureted hydrogen	.20

CHAPTER IV.

THE CARBONIFEROUS ROCKS AS A SOURCE OF OIL AND GAS.

These rocks are found at the surface of the eastern half of the state, but the important reservoirs of oil and gas are restricted to the areas where the coal measures constitute the surface formations. The producing strata have a great range stratigraphically, the lowest being the Berea grit, while the highest lie in the Monongahela formation or Upper Productive Coal Measures. These sands and their relative positions are shown in Chapter I. As will be seen from what follows this was the first territory developed in the state, but it is now greatly surpassed in production by the Trenton limestone.

OIL AND GAS IN MORGAN COUNTY.

Two pools of oil and one reservoir of gas have been discovered in this county:

1. The Chester Hill oil field;
2. The Buck Run oil field;
3. The McConnellsville gas field.

With the exception of the last named, the producing sand is the First Cow Run. From this it follows that the wells are shallow, and hence the expense of drilling comparatively small. The territory has contributed much to the wealth of the county. The Chester Hill pool is one of the important ones in the state. It extends into Athens county on the south and Washington on the east, but for convenience will all be considered under the head of Morgan.

THE CHESTER HILL OIL FIELD.

Location and Area.—The oldest part of this field lies one-half mile north of the village Joy in Homer township, Morgan county. The land is known as the Dale and Boileau farms, and occupies section 2 and the south half of section 3. From this the productive strip runs south through section 1, and then entering Ames township, Athens county, passes southwest through sections 16, 12, 11 and 17. Starting again with the Dale farm and going east the productive strip extends almost to Chester Hill when it turns abruptly to the southeast, continuing in that direction for 3 miles and then curving again to the northeast it passes through sections 7, 1, 8, 2 and 3. From this locality it enters Wesley township, Washing-

ton county, where it follows the valley of Wolf creek almost continuously as far east as Brown's Mills, and then bears off to the southeast for a distance of 3 miles. The length of this strip is nearly 25 miles. Nowhere has it a width exceeding one mile, and in some places there is room for a single row only of wells. Notwithstanding the fact that it lies in three counties, it will, since it forms a continuous pool, be considered wholly in this place.

Discovery and Development.—The residents of the fertile valley of Federal creek just north of Joy recognized "surface indications" of oil from the time of settlement of the territory. An oily substance was sometimes seen floating on the water of the creek, and when a hole was dug in the valley oil would sometimes gather in it. It was not until 1860, however, that a well was sunk in search of the strange smelling substance which found its way to the surface. The pioneer well is said to have been drilled by S. S. Teller, of Franklin, Pa., on the Joshua Bishop, now the Boileau farm. At the depth of 65 feet an 8 barrel producer was secured. It produced about 20 years and then was abandoned.

In the summer of 1860 a company was formed at Lancaster, Ohio, with a capital stock of $1,000,000.[1] It bought the Joy (now Dale) farm of about 400 acres for a sum reported at $375,000, and in the winter of 1860-61 began drilling directly across from the Boileau well, securing a 20 barrel producer. These wells caused great excitement, and the narrow valley was filled with speculators. The land was divided into small tracts, sometimes a quarter of an acre on which two or three wells might be drilled. These patches sold for extravagant amounts; thus for one-half an acre, on the Bishop farm, on which there was a ten barrel well, $10,000 were paid.

During the summer of 1861 probably 25 wells were completed or being drilled in the field, and it is estimated by an operator who resided in the territory at that time that 50 men were working on the Boileau and 100 on the Joy farms. The valley was dotted with wells, most of which have been abandoned, and the very location of many forgotten. The dry holes and the wells which had ceased to be profitable were filled with sand hauled from the creek to prevent the water from reaching the oil rock, and this helped to obliterate many of the early locations. From what has been said it is apparent that the two tracts most prominent in the early development of the field were the Bishop and Joy farms, and the early history of the territory is simply the record of these two places.

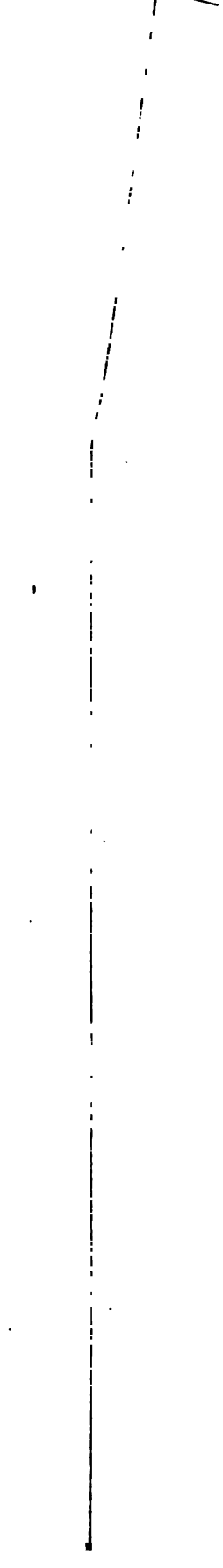
The Bishop farm consisted of 325 acres, and in the early sixties sold for the munificent sum of $100,000. Doubtless when the speculative era was at its highest, and this property was divided into small lots, it commanded a much larger figure. A number of the wells drilled during the civil war are still producing. Thus one located in the northwest corner of

[1]These figures are reports. No records are obtainable.

the place, and drilled probably in 1861, with a depth between 70 and 80 feet, has been yielding oil during the greater part of the past 40 years. It was never shot until 1897, and in 1900 was producing less than one barrel per day. Another of these pioneers stands a few hundred feet south of the last well, on the north bank of Federal creek. It was drilled in 1862 probably, is 72 feet deep, and is reported to have started at from 30 to 40 barrels per day. It had not produced long, however, until there was a heavy drop in the price of oil, and the well was closed until about 1880, when it was operated for a short time, and then again closed until 1892. Not until 1898 was it shot, and then with only ten quarts. Other wells in the valley date back to the civil war, but those on higher land were drilled within the past few years. The pioneer drillers here as elsewhere regarded the productive territory limited to the valleys. The old wells when first drilled usually produced sufficient gas to force the oil to the surface, sometimes to throw it to the top of the derrick; but at present the gas pressure is so small that the wells all have to be pumped.

The Joy farm, as has already been stated, was sold in 1860 for $375,000. The company worked assiduously and soon secured a number of producers, some of which are still being pumped. Well No. 4 was one of the first in the valley. The bottom of the Cow Run sand was found at 85 feet, and the Cambridge lime was struck at 92 feet. It still (1900) produces 4 barrels every 12 hours, but to secure this, 400 barrels of salt water have to be pumped. Another of the interesting wells is No. 2, which was drilled between 1861-63, and at first was thought dry, and so abandoned. Two years later it changed hands, was cleaned and put to pumping, and began producing 10 barrels daily. About 1870 the Mansfield Petroleum Company secured the lease, and shooting the well with a quart of nitro-glycerine, was rewarded with a production of 80 barrels per day. From that time it has produced continually, but its production has gradually diminished. In 1897 it was estimated that the well had yielded $120,000 worth of oil..

The Joy farm has changed owners a number of times since 1860. The first company, though it paid a large sum for the property, seems to have fared very well. Of the $1,000,000 capital stock it is said that $500,000 was sold at par in New York, and the remaining half advanced 50 per cent. in price and then one-half of it sold to New York parties. The Mansfield Petroleum Company sold out to Dale for $26,000 at a time when there were only two producing wells. Later the new owner having become discouraged, made complaint to the Mansfield Company, which reduced the price it was to receive by $4,000. Dale operated the property under the name Midland Oil Company, and began drilling wells as soon as he came in possession of the property, but did not secure a large production until 1893-94, which period marks the beginning of the modern history of the field. Later Dale leased to Haskell & Liken, but afterwards



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bought their lease and then leased it to the present operators, Reusen, Shedd & Company, receiving $80,000, the company taking possession March 22, 1900.

When the field was being opened much of the oil was hauled in barrels to McConnellsville and Stockport, but the greater part was taken to Big Run and from there shipped by rail to Marietta. About 12 years ago Dale laid a pipe line to Sharpsburg, from which point the oil was transported in tank cars. When the Corning pipe-line was laid in 1893 a branch was run to the Joy field, but later as the territory was extended a line was laid direct from Joy to Elba.

The Dale farm is much larger at present than it was when Joy sold it in 1860, and now comprises 965 acres. The present operators are drilling new wells and making improvements in other ways. On July 17, 1900, there were 55 wells pumping, and the daily production during the previous month averaged 107 barrels. The best well on the place at that time was No. 49, which produced 20 barrels every 12 hours. It had an initial production of 40 barrels per day when drilled in August, 1898.

Reusen, Shedd & Company have extended their property by purchasing the Hopkins farm on the south and the Boileau on the east, the two comprising 480 acres. In August, 1902, there were 66 wells on the Dale farm proper, and these were producing 120 barrels per day. The best well secured in recent years produced 85 barrels in 9 hours. The company keeps a string or two of tools at work almost continuously, and within a year will have the farm drilled over. On the Hopkins and Boileau farms the company had 21 producers, the daily production of the 87 wells combined being 143 barrels.

Wells having a daily production of only an eighth of a barrel are now pumped, a condition made profitable by connecting the wells tandem fashion with a gas engine. The latter is of 20 horse-power, and it is claimed could pump 100 wells if they were properly grouped. Sometimes the engine room is not visited except at starting and stopping, but generally some one drops in a time or two during the day to see that all is well. The saving in time and money by this form of power is immense.

A start in the development of the territory lying between the Dale farm and Chester Hill was begun in 1892, when J. A. Lovell leased 40 acres off the northeast corner of the Dale farm and drilled 7 wells, all of which were producers. No pipe-line had been laid in the field yet, however, and the lack of shipping facilities caused Lovell to suspend operations until 1895, when having been joined by H. E. Smith, he drilled 10 wells on the McElfresh farm, but later sold this property to the Cumberland Oil Company. In the fall of 1897 Lovell, in company with H. C. Lord, leased the L. and J. Mozier, Clark Woolman and John Morris farms, on which they drilled 87 wells during the following 2 years. Of this number 76 were producers and only 11 dry holes. In 1899 these farms

became the property of the Cumberland Oil Company. In 1897 P. B. Vore drilled a well on the Hopkins farm, still farther east, and, securing a small producer, sold the lease to the Octo Oil Company, of Pittsburg, which drilled 25 wells on the farm, 20 of which were producers. A year later H. H. Burns, of Mannington, West Virginia, purchased from Swayne and Bailey for $7,000 the lease on the second J. Mozier farm, and in 1899 drilled 20 wells on the place, 16 of which were producers. These operations seemed to have determined the limits of this part of the field, and the following year was given to the development of the territory confined within these lines, though some effort has been made to extend the productive territory. In 1899 drilling began actively in the territory south of the Dale farm, and has been progressing since that time. In 1902 wells were being sunk west of Federal station on the M. C. & C. railroad. The sand in a valley was found at 53 feet, the interval between the Ames limestone and the oil rock being 65 feet. The wells are small and the sand spotted, so that very little can be expected from this part of the field.

In the spring of 1899 a well was drilled on the land of E. J. Lambert, two miles south of Chester Hill. When put to pumping it started at 60 barrels, but the production decreased so rapidly that the well was abandoned the following December. Within a year 40 wells were drilled in this field, one-half of which were failures. In December, 1900, the Southwest Petroleum Company and A. J. Lovell bought the pool for $37,000, the production being 37 barrels per day. The first well was drilled on the Crayton farm between two dry holes 400 feet apart, and a 30-barrel producer secured. With this encouragement other wells were drilled in quick succession and the pool was soon connected with the production lying to the northwest and to the northeast.

While the territory west of Chester Hill was being developed the drill was busy in the valley of Wolf creek, east of the village. Oil had been known in this valley for nearly 40 years. A well is reported to have been drilled in 1864-5 along this stream on the Mercer farm, in the northeastern corner of Wesley township, Washington county. It produced for a short time only, but demonstrated the existence of the liquid. However, this discovery was of no pecuniary importance, since further exploration was not made for 35 years. The first of the modern producers was drilled in March, 1899, on the northeast corner of section 2, Marion township, Morgan county. Other wells followed in quick succession, and a small pool was developed which later was connected with the principal strip along the creek.

In the early spring of 1900 Lane & Vanlaw drilled a well in the extreme northwest corner of Wesley township, Washington county, on the H. A. Vanlaw farm, about one-eighth of a mile from the creek. A small producer was secured, and another well was begun. Before the latter

was completed, however, H. H. Burns had drilled on the Russell farm, on the north bank of the creek, securing a well having an initial production estimated at 190 barrels daily. Naturally, Lane & Vanlaw, whose lease extended to the creek, and included land just opposite from Burns', located their next well directly on the bank. The First Cow Run sand was struck at a depth of 287 feet, and the well began to flow at once. At this stage the drill was stopped until more tanks could be secured; they then continued drilling, until the sand, having a thickness of 13 feet, had been passed through. The output of the well increased greatly, having a production of 1,200 barrels the first day, according to the estimate of Mr. Vanlaw, one of the operators. Others, however, have estimated the production as low as 400 barrels. Wells were at once started on both banks, and in every case a good producer was secured, though they were much smaller than the one just described. In July, 1900, 12 drills were at work along the creek in the immediate vicinity of the Vanlaw farm.

About one mile southeast of the last tract another productive strip was discovered in June, 1899. The central part of this was occupied by the Zumbro farms. It was situated principally on hilly territory, a short distance from the creek, though the latter runs directly across the eastern end of the belt. This field, too, was very active in 1900, the principal extension being east of Wolf creek near the place where it is joined by Coal run.

In March, 1900, a producing well was drilled on the Yarnell farm, near Brown's Mills. Two additional wells were drilled in quick succession. On the 6th of June well No. 4 was completed and began producing 1,400 barrels per day. In all 16 producers and 5 dry holes have been drilled on the farm. In May, 1900, the production was 20,000 barrels; in July, 1901, 2,904 barrels; in July, 1902, 1,965 barrels. Naturally, the drill moved out in all directions from this farm, and the limits of the territory were soon determined in all directions except the southeast.

It is seen from what has been said that work in the Chester Hill field began at several points at about the same time. Later work has connected these pools, forming a continuous strip from Federal to a point 3 miles southeast of Brown's Mills. Between the latter and Moore's Junction several small pools have been found, and not improbably these will be connected, forming a continuous strip to the Ohio river.

In the southwestern corner of Windsor township, Morgan county, a small pool of oil was discovered in 1901. It starts near Dale P. O. and runs northwest in a discontinuous manner for nearly two miles, and then due north for another mile. The strip is very narrow, sometimes containing one row only of wells. The producing sand lies just above the Cambridge limestone and so is the First Cow Run. It is decidedly patchy, and appears to be restricted to the producing territory. The best wells started at about 40 barrels and the average at perhaps one-half that

amount. The number of dry holes is nearly as numerous as the producing wells. The southern extremity of the pool lies within one mile of the Chester Hill field proper and the two may eventually be connected.

Three miles northeast of Chester Hill a small pool was discovered in 1899, the first well having been drilled on the land of Samuel Milner. The First Cow Run sand was found at a depth of about 310 feet. It lay about 90 feet below the Ames limestone, but was so thin that it made nothing better than a show of oil. The best well on the place had an initial production of 30 barrels daily, but a year later had decreased to three barrels for a corresponding period. In this well there was a production from two sands,—(1) The First Cow Run, and (2) the Wolf Creek or Milner, which lies about 90 feet above the former. The three wells on this place were producing conjointly four barrels daily, when it was visited in July, 1900. The oil from the tank on the farm had a gravity of 46 B.

About 14 wells have been drilled on the adjacent farms owned by Stephen Milner, Joel Starlin and J. F. Calvert. All went to the Cow Run sand. The producers found were small, the ten wells having a daily production of 12 barrels only, when the locality was visited.

Geology of the Field.—On the Dale farm, near Joy, the Pittsburg or Federal Creek coal lies 180 feet above the valley, while the hill tops extend about 200 feet higher. The Ames or Crinoidal limestone lies just above drainage on this farm, and the interval between it and the Pittsburg coal is 170 feet. Just below the village of Joy this limestone passes under drainage, but appears again farther west near Federal and south near Amesville, Athens county, where it is finely shown in the valley, and where it received its name. It is very persistent and is found in every well in the vicinity of Joy. The formation does not ordinarily exceed 2 feet in thickness. It is filled with fossils, especially crinoid stems, and is very hard, giving a metallic ring when struck by the tools, and so is easily recognized by the driller. These characters make it one of the most important geological landmarks both above and below drainage in the shallow territory of southeastern Ohio. Another well-known limestone in this district is the Cambridge, which is thicker than the Ames but is much less fossiliferous. Lying as it does either immediately below the First Cow Run sand, or separated from it by a few feet only of shales, it serves as a base, which when reached by the driller shows that the position of the oil sand has been passed. Since the strata in this part of the state dip to the southeast, the lime bearing formations under consideration lie farther below the surface in that direction and cannot be satisfactorily located farther east than Brown's Mills. This may be due to the disappearance of the rocks in question; or it may result from the fact that heavier drilling tools are used, which may pass through the thin limestone so rapidly that the driller does not recognize them.[1]

[1]The Ames limestone is found above drainage in the eastern part of Washington county, where the Newell's run anticline crosses the Ohio river.

Aside from the two limestones and the oil sand, the underground strata are not well marked or conspicuous over a wide area. They are composed of shales and sandstones, the former greatly predominating. One of the best-known of these is a bed of red shales having a thickness near Joy P. O. varying from 15 to 40 feet, and known among the drillers as the "Big red." It lies above the Ames limestone, as shown by logs which follow. Above the "Big red" are found large beds of shales, sandstones, limestones and the Federal creek coal, to which reference has already been made. None of the latter, however, can be traced over an extensive area. The coal seam is lost almost as soon as the driller moves east from the Federal creek valley, while the limestones are not continuous like the Ames or Cambridge.

The succession of strata is shown by the following well records:

Well on farm of Lewis Morris, section 24, Ames township, Athens county. Log furnished by E. M. Woodin:

	Thickness of stratum. Feet.	Total thickness. Feet.
Gravel	10	10
Ames limestone	2	12
White sandstone	12	24
Blue shales	20	44
Red shales	20	64
Blue shales	15	79
Red shales	5	84
Dark shales	10	94
Sandy shale, place of First Cow Run sand	33	127
Cambridge lime.		

The following is the log of gas well No. 1 on the Dale farm, Homer township, Morgan county, and was furnished the survey by G. A. Faires, Superintendent of the Reusen-Shedd Company. The record is more interesting than most others obtained in this field, since it extends to the Salt sand:

	Thickness of stratum. Feet.	Total thickness. Feet.
Red shales	29	29
Blue shales	3	32
Red shales	10	42
Blue shales	30	72
Dark sand	5	77
Dark shales	1	78
Gray sand	9	87
First Cow Run sand	20	107
Soapstone and shales	58	165
Coal	2	167
Soapstone and shales	15½	182½
Dark sand	3	185½
Soapstone and shales	23½	209

	Thickness of stratum. Feet.	Total thickness. Feet.
Black shales	9	218
Gray shales	37	255
Black shales	35	290
Sand rock	36	326
Shales	91	417
Sand rock	26	443
Shales	47	490
Dark sand rock	6	496
Shales	6	502
Sand with gas	8	510
Shales	2	512
Sand rock	3	515
Dark shales	9	524
Light shales	36	560
Salt sand	52	612

Below is the log of a gas well on the same farm. It was drilled in the fall of 1899, and furnishes sufficient gas to run two gas engines, the hotel and one residence.

	Thickness of stratum. Feet.	Total thickness. Feet.
Red shales	40	40
Blue shales	12	52
Red shales	10	62
Yellow shales	17	79
Gray sand	3	82
First Cow Run sand	2	84
Blue shales	6	90
Cambridge limestone	2	92
Dark and light shales	178	270
White sand	40	310
Black shales	65	375
Gas sand	9	384

This sand is known locally as the Second Cow Run, but since in the typical locality the interval between the two Cow Run sands is approximately 400 feet, and since in this well the interval is 291 feet only, it is safe to state that the sand in question is not the Second Cow Run. As will be discussed in another chapter, the term Second Cow Run is used by the driller and operator in a very loose way. It is applied to almost any sand lying from 100 to 500 feet below the First Cow Run. There is no method of distinguishing the sand except by its distance from the first one, and it is not widely recognized in southeastern Ohio.

The following log is from well No. 1 on the A. Mozier farm, one mile west from the village Chester Hill. The record was kept by W. H. Knight, the measurements having been made with a steel line:

	Thickness of stratum. Feet.	Total thickness. Feet.
Surface material	3	3
Limestone	31	34
"Big red" (shales)	125	159
Sandy blue shales	22	181
Ames limestone	2	183
Blue shales	4	187
Black shales	8	195
Blue shales	10	205
Red shales	16	221
Dark shales	4½	225½
Limestone	2½	228
Blue shales	21½	249½
First Cow Run sand	12	261½
Gray shales	20	281½
Cambridge limestone.		

The following is a log of a well on the Lucinda Johnson farm, situated about 3 miles southwest of Brown's Mills:

	Thickness of formation. Feet.	Total thickness. Feet.
Gravel	4	4
Red rock (shales)	10	14
Light shales	13	27
Sandstone	10	37
Limestone and shales	103	140
Light shales	10	150
Limestone	15	165
Red rock (shales)	5	170
Light shales	5	175
Mercer sand	35	210
Limestone	5	215
Light shales	15	230
Red rock (shales)	5	235
Light shales	10	245
"Big red" (shales)	70	315
Light shales	15	330
Red rock (shales)	10	340
Sandstone	4	344
Light shales	20	364
Black shales	12	376
Light shales	8	384
Red rock (shales)	25	409
Light shales	8	417
Shales	10	427
Gray sandstone	5	432
Dark shales	15	447
Light shales	13	460
Cambridge limestone	4	464
Shales	9	473

It will be observed that in this section the Ames limestone is not reported. In fact, it is never recognized with certainty beyond Brown's Mills. The section shows the Cow Run sand also absent, its place being occupied by shales.

One more record only will be given. This is a well on the Mary J. Morris farm, near Brown's Mills. The data were furnished by A. J. Lockard:

	Thickness of formation. Feet.	Total thickness. Feet.
White shales	6	6
Red rock (shales)	24	30
White shales	10	40
Sand rock	4	44
Black shales	3	47
White shales	4	51
Limestone	12	63
White shales	2	65
Limestone	5	70
Shales and limestone	12	82
White shales	18	100
Limestone	3	103
White shales	6	109
Black shales	4	113
White shales	4	117
Gray sand	8	125
White shales	8	133
Limestone	4	137
White shales	12	149
Red rock (shales)	12	161
White shales	16	177
Black shales	20	197
Limestone	10	207
White shales	5	212
Black shales	20	232
White shales	12	244
Red rock (shales)	12	256
White shales	4	260
Black shales	4	264
Limestone	4	268
Red rock (shales)	4	272
Black shales	4	276
"Big red" shales	30	306
White shales	4	310
Ames Limestone	1	311
White shales	48	359
Sand	4	363
White shales	4	367
Black shales	20	387
Sand	10	397
Black shales	4	401
First Cow Run sand	29	430
White shales	17	447

The depth of the wells, of course, varies with the surface altitude; but few, if any, exceed 700 feet. One on the Hoon farm, at the end of the bridge at Brown's Mills, struck the oil sand at 393 feet.

The Oil Sand.—This, as has already been stated, is the First Cow Run. Its position below the Ames limestone varies considerably. An examination of 11 well records taken at random on the Dale farm showed a maximum and minimum distance of 92 and 71 feet, with an average of 82 feet; and the latter figure may be taken as an average for all the territory where the sand in question is found. It is rare that the interval exceeds 100 feet, or is less than 65 feet.

The sand varies much in texture. Sometimes it is so coarse as to make a conglomerate. Pebbles having a diameter of three-fourths of an inch are occasionally found, while those one-fourth of an inch are common. From these extremes the rock grows finer until it becomes so compact that it cannot contain oil or gas in commercial quantities. Sometimes the higher portion of the sand is quite fine or compact, and then is known as the "cap rock" among the drillers; while at other places the upper part is quite porous and contains important quantities of oil or gas. The sand is composed almost wholly of light-colored quartz, but other minerals, such as pyrite and mica are not uncommon. It is nearly colorless when first brought to the surface, but frequently changes to a yellow-brown when exposed to the atmosphere.

The pay streak, like the sand as a whole, varies much. It is usually the coarser part, and has a darker color. The drillers frequently describe it as having the shade of brown sugar. In thickness it commonly varies from 8 to 15 feet, but smaller and greater measurements are not rare. It is usually quite soft, so that the drill passes through it very quickly. Generally the pay lies a few feet below the top of the sand, but sometimes it is found at the summit. Occasionally also it lies at the bottom. Rarely the driller reports the pay rock divided by a few feet of shale, and then he announces the presence of two pays. An illustration of this is found on the Mozier farm, near Chester Hill, where the upper pay, having a thickness of ten feet, is separated from the lower one, having the same thickness, by ten feet of shale. Four wells similar to this have been found on the Dale farm.

In total thickness the sand varies greatly. Thus on the Dale farm 14 well records, taken at random, disclosed thicknesses ranging from 4 to 30 feet, with an average of 15. The rapidity of change is well shown on this farm by two wells 125 feet apart. One has 7 feet of the sand and the other 30 feet. The greatest thickness yet reported is in well No. 17, on the Mozier farm, where 47 feet of sand were found. It is not uncommon to find thicknesses of a foot or less, but such commonly occur along the margin of the field, and are rarely productive.

If there is one character of this sand which is more conspicuous than another, it is the discontinuous nature. This is often so prominent that it might almost be said to form a series of lenticular basins. A driller of wide experience in this field has estimated than in 90 per cent, of the dry holes near Chester Hill no sand was found, and it is a common statement among the drillers and operators that the failure to secure oil is due to the absence of sand. This is not always the case, however. When the sand disappears its place is taken by shales. These are sometimes siliceous, closely resembling the sand rock; but at other places they have no resemblance to the rock in question.

The texture of the sand is well shown by the different treatment with reference to torpedoing the wells. Those along the western end of the field are shot as soon as the drilling has been done, while farther east many of the wells have not been shot until a year or two after completion. The more open or porous the sand the less need of nitro-glycerine.

Oil has been found in a few wells near Chester Hill in shallower sands. One of these is the Wolf creek or Milner sand, which lies a few feet above the Ames limestone. Oil has been secured also in a stray lying about the same distance below the Ames. These, however, are of very little importance commercially. Their relations are shown below:

	Feet.
Wolf Creek sand	20
Shales	20
Ames limestone	2
Shales	25
"Stray" sand	18
Shales	40
Cow Run sand	15

One other sand should be mentioned. This is on the Mercer farm, about one mile due north of the junction of Coal run and Wolf creek. It was here that a well was drilled about 35 years ago, as has already been mentioned. The wells, however, are shallow, the oil sand being found at a depth of from 140-150 feet, while the First Cow Run probably lies 350 feet below the surface. This sand, which lies above the "Big red," is the highest stratigraphically of the producers in the northwestern part of Washington county. It is unimportant in a commercial sense, and does not give promise of becoming even a moderate producer. The sand occupies a similar position to that of the Mitchell, near Marietta.

In 1902 two deep wells were drilled east of Chester Hill and a reservoir of gas was the reward. The rock pressure was 400 pounds, and the open flow of one, measured by the Standard Oil Company, was reported to be 3,500,000 cubic feet per day. The second well had not been measured, but was reported similar to the first one. The gas has been piped to Chester Hill, where it is sold for 18 cents per thousand, with 10 per cent. off for cash.

Outside of the territory now described many wells have been drilled in search for oil. The valleys of the principal streams, especially that of Federal creek, have been the site of the most active operations. In sections 2, 7, 8, 13 and 14 of Ames township, Athens county, many wells have been sunk to the First Cow Run sand in recent years, but little more than a show of oil has been found. In the northeast corner of section 5, on the Linscott farm, several small producers have been secured, but 3 miles farther west, along the line of section 17, four wells have been drilled to the Cow Run sand, but nothing was found to compensate the operator for his outlay. In the northwest corner of Berne township, Athens county, several dry holes have been drilled. Two of these were on the O. & A. Gifford farm, in the northern half of section 30, and reached the Berea grit, which is reported to have been struck at a depth of 1,300 feet. These wells yielded much salt-water, but little oil, and are now abandoned. The wells in the adjacent sections of 29 and 30 went to the Cow Run sand and were all failures. Several Berea wells have been drilled near the Joy field, in Morgan county. In 1896 such a well was drilled on the L. L. Joy farm, in the southeast quarter of section 31, Homer township. The Berea was found at a depth of approximately 1,300 feet, but when this had been penetrated to a depth of 28 feet salt-water began to appear. Some show of oil and gas was found; but when the well was shot, the flow of brine increased, and after pumping for a time it was abandoned. Later a Berea well was sunk on the Hopkins place, in Marion township, just beyond the northeast corner of section 26. The sand there is reported divided as follows:

	Feet.
Berea (Upper stratum)	24
Black shale	6
Berea (Lower stratum)	15

Nearly 20 years ago a Berea well was drilled on the Boileau farm, near Joy. It is said to have reached a depth of 1,218 feet, but found nothing more valuable than a show of oil. About the same time a well was drilled on the Eli Swayne farm, in the northeast quarter of section 3, Homer township, and found the Berea somewhere between 1,300 and 1,400 feet. Neither oil nor gas was found in paying quantities, and so the well was abandoned. Many holes, aside from those here recorded, have been drilled both north and south of the productive strip, but the results achieved have been entirely of the negative kind. Doubtless many additional wells will yet be drilled in Homer and Marion townships, and considering the patchy nature of the sand it seems safe to predict that other small but valuable pools will yet be found.

THE BUCK RUN OIL FIELD.

Location and Area.—This field is located in the northeast corner of Union township, Morgan county, and in July, 1900, was confined to sec-

tions 1, 2, 3, 11 and 12. Work done since that time has not materially changed the field.

Discovery.—The people living along the valleys of Buck run and Wolf creek had, from the time of the settlement of the territory, noticed oil escaping at numerous points in the valleys of those streams, and they concluded from this that there might be reservoirs of oil in the rocks below. In the fall of 1860 a well was drilled on the east bank of Wolf creek, a few hundred feet above the point at which Buck run units with it, on the Ritchey farm, now owned by John Grey.

The well was a success, though only 37 feet deep. The oil sand lay immediately below the Ames or Crinoidal limestone. This lime rock has a thickness ordinarily less than 2 feet, is very hard, and so is easily recognized by the driller. It is filled with fossils, especially crinoidal stems, and is widely known among the oil men of southeastern Ohio as the "fossil rock." In fact, it is one of the geological landmarks of the driller, since one of the richest oil sands in that part of the state lies about 90 feet below it. The oil from this well being thick and heavy, was used for lubricating purposes, and was hauled in wagons to McConnelsville, where it found a ready market. At first the well was pumped by hand, but later by horse-power. The well was long-lived. It was not until about 1875, when the production had diminished to one barrel per week, that the well was finally abandoned.

Development.—The second well in this field was drilled on the Lewis Balding, now the Stanton farm. This well, however, was deeper, being the first one to strike the First Cow Run sand, which was found at a depth of about 120 feet. According to the best information obtainable at this late period, the well produced at first about 20 barrels per day, and it is of interest to report that it is still (1900) a producer. About 6 years ago the well was drilled deeper and cased to a depth of 40 feet to exclude the surface water. This well was pumped by horse-power from the first.

The Greathouse is another of the wells drilled in 1861. It was named after the driller and is located on the D. D. Scott farm, in the northeast quarter of section 11. When the sand was struck oil began flowing, and the necessary tanks not having been provided, dams were constructed across the creek, and in this manner the oil was saved until tanks could be provided. It is said that from 8 to 10 teams were kept busy hauling the product of this well to McConnelsville, 5 miles distant. About 1890 an attempt was made to clean the well, but in doing this a string of tools was lost in it, and the well abandoned. A new one was begun at once about 6 feet from the old well, and it has proved itself a worthy successor of Greathouse No. 1. In July, 1900, it was producing 2½ barrels per day.

Another of the pioneer wells, still producing, was drilled in 1865 on the James Scott farm, in the central part of section 2. This farm is prominent in the oil production of the field, and so a line or two concerning the

history of the tract in question will not be out of order. About 1860 Mr. Scott leased for oil purposes a part of his farm to John Henry, of the adjacent village, Morganville. The leaser drilled 3 wells, 2 of which were total failures, while the third produced about 2½ barrels only per week. After this well had been producing approximately 2 years, Mr. Scott purchased it and in 1865 had it shot, with the hope of increasing the production, but the shot ruined the well, and it was abandoned. In 1865 Mr. Scott again leased the tract under consideration, amounting to 15 acres, to the Chautauqua Petroleum Oil Company, of Chautauqua, New York, for which he was to receive one third of all the oil produced. Drilling was delayed until the company brought the necessary tools from New York, but 4 wells were completed that year, only one of which was a producer. This well, "The Chautauqua," yielded from 40 to 50 barrels per day for months, and it is claimed that if the pump had been worked to its full capacity the well would have produced 100 barrels per day. By 1869 the well had decreased to 6 or 7 barrels per day, and its owners, regarding it no longer sufficiently profitable, sold it to Mr. Scott, owner of the land, and to his cousin Andrew Scott. The price paid for the well and all machinery was $1,100. The new owners of the well pumped it regularly until the refinery, "The McConnelsville Carbon Oil Company," went into bankruptcy in about 1873. Since that time it has been pumped irregularly and at present is a very small producer. The well is 118 feet deep. Water was found in the "fossil rock," which there lies about 30 feet below the surface, but was shut from the oil rock by the "seed-bag," which played so important a part in early oil development. The production of this well and market value of the oil from 1865 to 1873 was as follows:

	Barrels produced.	Value.
From August 15, 1865 to June 22, 1869.....	2,420	$23,442
From June 22, 1869 to February 22, 1873....	1,610	6,692
Total.....	4,030	$30,134

It is impossible to learn at this late date how many wells were drilled in this field during the time of greatest excitement, from 1861-65. From the best information obtainable, however, it appears that the valley of Buck run was dotted with wells as far up as and beyond Morganville, but that exploration did not extend into the adjacent valleys of Oliver run and Wolf creek.

By 1866 the greatest excitement in the valley was past, and when the refinery at McConnellsville was discontinued a few years later the best market for the oil was destroyed, though some is said to have been shipped by boat later to Marietta. After 1875 there was very little done in the field for many years, and the prospects were that it would never again attract the attention of oil producers. However, the Corning pipe-

line, which was laid in 1893, and passed near Buck run, encouraged the producer, since it removed the expense of hauling the oil to market. By 1897 considerable work was being done, and in 1899 the existing "boom" began. At present (July, 1900) 17 drills are at work, chiefly along Oliver run, a small tributary of Buck run, and along Wolf creek, about one-half mile from Oliver run. Since the wells are shallow, those in the valleys usually not exceeding 125 feet, the drill makes rapid progress, and it should not be long until the limits of the field are determined. In the sixties operations were confined to valleys, the driller having the mistaken idea that the productive territory did not extend beneath the adjacent hills. Now, however, the high lands as well as the valleys are tested, and fair producers found.

The following are the principal firms operating in the field at date of writing:

Malta Oil Company.
Oliver Run Oil Company.
Jerry Buckley.
Christy Brothers.
Elmer Taylor.
Buzzard & Gibson.
Ghering & Mahaffey.
Moore & Downing.

Geology of the Field.—The surface rocks are in the main those belonging to the Conemaugh formation or Lower Barren Measures, the hilltops alone rising to the horizon of the Pittsburg coal. The latter is represented by little more than a black streak, but the white limestone which underlies the coal is a prominent feature of the country.

The following log of a well on Oliver run represents the general succession in the field:

	Thickness of stratum. Feet.	Total thickness. Feet.
Light colored sand rock	43	43
Red rock (shales)	90	133
Blue core (1st limestone)	3	136
Blue shales	10	146
Red rock (shales)	20	166
Blue core (2nd limestone	3	169
White and red shales	30	199
"Fossil rock"—Ames limestone	2	201
Dark gray shales	50	251
Pink shales	6	257
Soapstone	15	272
Sandy shales	25	297
Black shales	35	332
Cambridge limestone	5	337
Black shales	70	407
Coal (No. 7)	6	413

In this well the Cow Run sand was absent, its place being occupied by the sandy shales lying from 40 to 65 feet above the Cambridge limestone. This would make the interval between the base of the Ames limestone and the top of the Cow Run sand 70 feet, and this is the distance that is usually given along Oliver run. However, a quarter of a mile distant, along Buck run, the interval is 90 feet, and this is about the normal distance between these two formations in southeastern Ohio. The apparent contraction of the section along Oliver run raises the question whether the oil sand there is not a "stray" and the place of the Cow Run sand occupied by the black shales, which directly overlie the Cambridge limestone.

Salt-water is found everywhere in the field, but usually not in sufficient quantities to cause serious trouble to the operator. Fresh water is commonly found in the limestones ("blue-cores") above the Ames and in the latter stratum, and salt-water in the Cow Run sand. In the early days water was shut from the well by the "seed-bag," which consisted usually of a leather bag filled with flax-seed, but occasionally oats, wheat or some other grain was used. The bag was tied around the tubing at such a point that when put in the well, it would stand just below the point at which the water entered. The grain becoming wet would swell, completely filling the hole, and thus prevent the water from reaching the oil sand.

The Oil Sand.—This is a clean, porous, quartz sand. The quartz is colorless and distinctly vitreous. Usually the grains are angular, but occasionally a well-rounded one is found. The rock, which is the First Cow Run sand, is much more open than the Berea. It has a thickness ordinarily less than 25 feet, the oil being found in the upper 10, and salt-water below. It is overlaid by a fine-grained shale, sometimes called soapstone by the driller.

Here, as elsewhere, the sand does not form a continuous layer, but is patchy. It may run out, and be replaced by a shale in a very small area, so there is more than the usual chance of failure in this formation. Not infrequently a belt in which the sand is wanting may run directly across a productive strip. If the Berea grit be taken as a representative of the persistent beds of the state, then the First Cow Run may be selected to represent the opposite type. Its treachery is unusual for even a sandstone.

The sand does not contain sufficient gas to make the wells flow. Search has been made in the deeper rocks with the hope of finding sufficient fuel to pump the wells, but this effort has been only partly successful. Four small gas wells have been found near the junction of Oliver and Buck runs in a seam of coal reported 7 feet in thickness, and lying 205 feet below the Ames limestone. This is the position of the Upper Freeport or No. 7 coal.

Oil Production.—The largest well that has ever been secured in the field did not produce more than 100 barrels per day. At present the

wells are all small, though one on the Spurrier farm, along Wolf creek, is reported to have started at from 50 to 60 barrels. The largest well along Oliver run had an initial production of 12 barrels, while the average for that locality is about 5 barrels. The total production for the Buck run field does not exceed 100 barrels per day. Since the wells are shallow they are quite profitable, though small.

The oil compares favorably with that found in the First Cow Run sand elsewhere. It has a low specific gravity, and a market value equal to the Pennsylvania oil. The field does not promise to become one of future importance, though it will doubtless be a small producer for many years.

Wells in Union Township.—In the vicinity of Ringold, Union Township, an effort has been made to locate a pool. About 1896 a well was drilled on the Withee farm, in section 16. It produced a little oil, and since 1899 six additional wells have been put down on the same tract, all but one of which yielded a small amount of oil. The wells have a depth ranging from 80 to 204 feet, depending on the surface altitude. The sand, which is the First Cow Run, varies from 10 to 37 feet in depth.

On the Williams farm, in the southern part of the same section, four wells have been drilled, with results even less encouraging than those mentioned in the last paragraph. On the old Parsons land, in section 15, four wells were drilled about two years ago. All were producers, but were so small that they scarcely warranted pumping. In fact, at the time when they were visited by the writer they had not been in operation for two months. Wells have been drilled at a number of places between Buck run and Ringgold without success, and it seems safe to say that no important pool lies in that vicinity.

THE McCONNELLSVILLE GAS FIELD.

Location and Area.—This is a narrow strip extending a little east of north or west of south. It lies partly within the corporation of McConnellsville, and crosses the river near the lower part of the town.

Development.—In the spring of 1889 a well was drilled on the east bank of the river about one-half mile northeast of the city. The Berea sand was found at a depth of 1,195 feet, but the gas liberated was so small that the well was abandoned. About the same time a well was drilled three-fourths of a mile north of the city. It supplied enough gas for one residence.

These wells were failures, but the people were not satisfied. Some believed that gas would be found if only the drill were forced deep enough, and accordingly it was decided to attempt to reach the Clinton or Lancaster gas rock. However, no company was found that was willing to back so expensive and hazardous an enterprise, but the city, through its council, provided $5,000 to explore further the territory. The well was located on the McConnellsville fair grounds, and work was begun Septem-

ber 3, 1894. The Berea was reached at a depth of 1,279 feet on October 24. It gave nothing more encouraging than a show of oil and gas, and many of the most intelligent citizens urged that the well be abandoned, and that the funds, of which a large part still remained, be used for drilling other wells near the city. The State Geologist was appealed to, and strongly advised that the well be abandoned, stating that even should the Clinton be reached and gas found, the expense of drilling such deep wells would be so great that the gas would be too costly to be used as a fuel. However, those in charge insisted on drilling deeper, and on November 8th work was resumed. Progress was very slow, and on March 14th, 1895, when at a depth of 3,186 feet, the tools became fast and the well was abandoned.

The following log of this well was kept by Mr. H. J. Travis, who kindly furnished it to the Survey. The stratigraphical names of the formation have been supplied by the writer. The well head is 725 feet above sea level:

Geological names of formations.	Driller's log.	Thickness. Feet.	Total depth. Feet.
	Surface material	15	15
Conemaugh Formation, or Lower Barren Coal Measures; Allegheny Formation or Lower Productive, and Conglomerate Coal Measures.	Fire clay	15	30
	Red rock (shales)	25	55
	Blue shales	30	85
	Limestone	15	100
	White shales	14	114
	Red shales	18	132
	Flint rock	5	137
	Blue shales	25	162
	Gravel rock	11	173
	Red shales	30	203
	White sandstone	14	217
	Yellow clay	15	232
	White sandstone	44	276
	Coal	2	278
	Shales	12	290
	Sandstone	6	296
	Shales	23	319
	Sandstone	39	358
	Shales	65	423
	Sandstone	20	443
	Gray shales	17	460
	Lime and gravel rock	35	495
	Shale and limestone	25	520
	Black shales	15	535
	Sand and shales	3	538
	Blue and brown shales	87	625
	Maxville or Mountain limestone	44	669
	Keener sand	40	709
	Blue shale and sandstone	86	795
	Big Injun sand	45	840

Geological names of formations.	Driller's log.	Thickness. Feet.	Total depth. Feet.
Cuyahoga Shale.	White shales	71	911
	Brown shales	119	1,030
	Blue shales	25	1,055
	Black shales	194	1,249
	Berea shale, Coffee colored	30	1,279
Berea sand.	Berea sand	17	1,296
	Blue shale	34	1,330
	Stray sand (gas)	15	1,345
	Bedford sandstone and shales	25	1,370
The Ohio Shales.	Black shales	70	1,440
	Sandstones and shales	66	1,506
	Black shales and sandstone	69	1,575
	Shales	60	1,635
	Bastard limestone	50	1,685
	Shales	270	1,955
	Shales and bands of limestone	9	1,964
	Shales and bands of sandstone	8	1,972
	Sandstone and limestone	58	2,030
	Shales	145	2,175
	Shales and limestones	71	2,246
	Shales	79	2,325
	Brown shales	55	2,380
	Coffee colored shales	82	2,465
	Black shales	18	2,483
	Coffee colored shales	97	2,580
	Limestone and shales	21	2,601
	Black shales	134	2,735
	Limestone and shales	159	2,894
	Flinty limestone and shales	38	2,932
	Brown shales	150	3,082
	Corniferous limestone, hard	2	3,084
	Flinty limestone	41	3,125
	Sandstone	8	3,133
	Limestone and sandstone	53	3,186

The presence of gas in the lower part of the Berea sand in this well encouraged further investigation, and in 1896 a well was drilled on the land of C. B. Bozman, about one-half mile east from the corporation line. The Berea there yielded a more liberal quantity of gas, and promised a moderate supply. In rapid succession wells were drilled in all directions from this one, until sufficient gas was secured to meet the demands of the town.

The Dresser Gas Company, which supplies McConnellsville and the greater part of Malta with gas had 18 producing Berea wells in July, 1900. Two of these are about one-half mile below McConnellsville, on the west side of the river, and the remaining 16 on the east side of the river. Two of the latter group are within the corporation limits. Besides these 18 wells the company has two shallow ones about three miles west of the

city, one on the farm of A. W. Powers and the other on the land of Mary Riley. The well on the first-mentioned farm is said to have been drilled nearly 40 years ago, but has been in use about 9 years only. The second well is reported to have been drilled 10 or 11 years ago. Both are now very small producers. The Dresser Company drilled its first deep well in 1896, and has sunk one or more wells of this type each year since.

In 1897 the Home Gas Company of Malta was established. In the summer of 1900 it had three producing wells, all of which were small, supplying approximately 50 families. The Dresser Company reports that it supplies 700 families. The charges are 10 cents per 1,000 cubic feet, but if the bills are not paid when due 10 per cent. is added. It is claimed that this rate does not pay the expense of operating the plant. Before the Home Company was established the rates were just double those stated.

The Gas Sand.—With the exception of the two wells noted, the sand is the Berea. This divides here, the two parts being separated by a bed of shales which is 30 feet thick on the west side of the river and 20 feet thick on the east side. The gas is derived entirely from the sand below the shales and is known locally as the "stray," that above the shales being considered as the Berea. The lower bed or "stray" ranges in thickness from 7 to 29 feet, and the upper bed is probably confined to about the same limits. Wells drilled near the river on the north side of the county show this parting, but on the east side of the county it disappears, and the same is true near the river 3 miles south of McConnellsville. The casing reaches through the Big Injun sand, a depth in the valley of approximately 800 feet. Below this no water is found until the Berea is struck. The quantity found there is not large, and is restricted to the upper stratum. The wells are shot with from 40 to 80 quarts of nitro-glycerine.

Rock Pressure of Gas.—The Dresser Company reports the closed or rock pressure of the gas as having ranged from 380 to 545 pounds per square inch in 1899. Before that date the pressure was never measured. The open pressure, and hence the production of the wells, has never been determined. That this is small is shown by the fact that 23 wells are required to supply the towns of McConnellsville and Malta, the combined population of which is perhaps 3,000.

The operators have the usual trouble from salt-water. During the winter months the wells have to be "blown" every other day, but during the summer this does not have to be done at all.

Within the past few years a number of wells have been drilled in the northern part of the county. In September, 1899, one on the land of William Porter, at Shawnee Junction, reached the Berea at approximately 1,125 feet, but neither oil nor gas was found. In 1897 a well was drilled on the Hite farm, on Island run, about one mile from Eagleport. This well made little more than a show of oil. It was pumped irregularly for a month, producing perhaps 20 barrels in all, and then was abandoned. In

1899 a well was drilled on the McCauley farm, about 2 miles northwest of the well just mentioned. The Berea was found at a depth of 1,175 feet, and was divided as follows:

	Feet.
Sandstone	12
Light colored shales	35
Sandstone and shale ("stray")	10

Below this a brown shale (the Bedford) was found. The well produced neither oil nor gas. A well drilled in June, 1900, on Cedar run struck the Berea at 1,073 feet, but neither oil nor gas was found. Other wells have recently been drilled in this part of the county, but all have been failures. It is reported that formerly 5 wells were drilled in this territory and all produced much oil. This report is in part responsible for the wells that have recently been drilled.

OIL AND GAS IN WASHINGTON COUNTY.

This county is one of the oldest producers of oil and gas in the United States. Forty years before the drilling of the Drake well near Titusville, Pennsylvania, in 1859, the county was yielding crude oil. The discovery resulted from boring for salt-water. One of the earliest of these wells was located on the Little Muskingum river, and was thus described by Dr. S. P. Hildreth, one of the pioneer geologists of the state, in a letter written in 1819 to Mr. Caleb Atwater, of Circleville, and by him published in the American Journal of Science in 1826:

"They have sunk two wells which are now more than 400 feet in depth. One of them affords a very strong and pure water, but not in great quantity. The other discharges such vast quantities of petroleum, or as it is vulgarly called 'Seneka oil,' and besides is subject to such tremendous explosions of gas for several days that they make but little or no salt. Nevertheless, the petroleum affords considerable profit, and is beginning to be in demand for lamps, in workshops and manufactories. It affords a clean, brisk light when burnt this way, and will be a valuable article for lighting the street lamps in the future cities of Ohio."[1]

That these early drillers for salt had some experience with natural gas is shown by the following extract from the same letter:

"There is a continual discharge of carbonated hydrogen gas from the well; and also from the bed of the creek on which the well is situated, at various places for the distance of half a mile. This gas is highly inflammable, and where there is a free discharge of it, will take fire on the surface of the water, on the application of a lighted stick, or the flash of a gun, and continue burning for days, unless put out by a heavy shower or a high wind. It was this discharge of gas that induced the present

[1] *Amer, Jour. Sci. and Arts*, Vol. X, p. 5, S. P. Hildreth.

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proprietors to search for salt-water. It being invariably found to accompany, all the salt-water, of any consequence, that has been discharged in this western country.

"It is this discharge of gas that brings the salt-water from such vast depths in the bowels of the earth, to the surface. And where water has been discovered, and the supply of gas has failed, the water has immediately sunk in the well, and could not, by any means used, be brought again to the top of the well."

Just as Washington county was one of the first producers of oil, likewise Marietta, the county seat, was one of the first distributors. The principal supply was derived, however, from West Virginia and not from Ohio. One of the pioneer firms was Bosworth, Wells & Co., who began purchasing the crude material from Bushford W. Creel, of Hughes River, West Virginia, in 1847 and continued until 1860. The firm shipped the oil to Pittsburg, Philadelphia, Baltimore, New York, St. Louis, Peoria, Chicago and Cincinnati. From 1848 to 1857 the firm received 33 cents per gallon for the oil, and from 1857 to 1860 40 cents per gallon.[1] The opening of the Pennsylvania field in 1859 destroyed the business of Bosworth, Wells & Co., in so far as it depended on the shipment of crude oil from the Hughes river territory.

While the crude material may have been used by the drillers and farmers adjacent to the wells for illuminating, it is probable that the chief demand for the oil in distant cities was for medicinal and lubricating purposes. It is said that large quantities were used in the manufacture of the Mexican Mustang and other liniments. The crude oil was at that day regarded as an excellent remedy for rheumatism, and indeed many so regard it at the present time.

The discovery of oil in large quantities in Pennsylvania in 1859 stimulated investigation wherever surface indications, consisting of oil floating on streams, or filling sands in valleys, or the escape of gas through crevices in rocks, were found. Among the tracts of this kind in Washington county was the valley of Duck Creek at Macksburg, in the extreme northern corner and the insignificant valley of Cow Run, in Lawrence township. Mr. F. W. Minshall[2] has already published an interesting account of the early developments in this field, but since this report is now out of print, the salient points are restated here with such additional data as the writer has been able to secure.

Discovery of Oil at Macksburg.—This was one of the first fields developed after the discovery in Pennsylvania. In the fall of 1860 Messrs. James Dutton, Alden T. Warren and John Smithson decided to drill a well on the land of William Rayley, situated in the valley of Duck creek, about one-half mile below Macksburg. The method of drilling was of the

[1] *W. Va. Geol. Sur.*, Vol. I, p. 142, I. C. White.
[2] *Geol. Sur. of Ohio*, Vol. VI, Chap. 6.

most primitive sort, the tools being raised by a hand lever. Necessarily the labor was arduous and progress slow. Fortunately it was not necessary to drill deep; at a depth of 59 feet oil was found in moderate quantity. It had a gravity of 28 deg. B., and because of this did not find a ready market, since it was too heavy to be used for illuminating purposes. However, its value as a lubricant was soon discovered, and thereafter the product was easily disposed of, commanding a price as high as $28 per barrel. The oil was hauled in wagons to Lowell, on the Muskingum, ten miles distant, and from there shipped by boat. The success of the Dutton well at once attracted the attention of operators elsewhere, and soon the adjacent territory was being tested. A little later it was decided to drill deeper, and at 140 feet below the valley of Duck Creek a second sand was found which produced quite largely. This is the equivalent of the sand found on Cow Run—to be discussed later—and now widely known in southeastern Ohio as the First Cow Run sand. It is known at Macksburg, at the present day, as the 140-foot sand. A year or two later a well was drilled on the Smithson farm, in the valley below Macksburg. At a depth of approximately 300 feet a small amount of oil was found, and this rock has been known as the Macksburg 300-foot sand. In 1865 a well was drilled on the Atkinson farm, just below Macksburg. At a depth of 500 feet a flow of oil, reported at 50 barrels per day, was found, and this stratum has since been known as the 500-foot sand. The same year a well was drilled to a depth of 800 feet on the Dutton farm, below Macksburg. It produced gas and some oil, and the oil rock has since been known as the Macksburg 800-foot sand.

The greatest excitement in the field was perhaps in 1864, when land was bought and sold at fabulous prices. Thus the Jacob Dearth farm, consisting of 200 acres, and adjoining the Dutton tract, just below Macksburg, was sold for $300,000. At that time there was one well on the tract which produced about ten barrels per day. The company never secured another producer. About the same time the James Dutton farm sold for $100,000. A small part only of the farm which exchanged hands was regarded as productive, since not more than a fraction of the territory lay in the valley, and this part alone was regarded as productive. Not until 1881 (Minshall) was the hill land adjacent to the valley tested.

The period of great excitement just alluded to was of short duration. The deeper sands did not meet expectations and the expense of hauling the oil to market was heavy. Besides the price of oil had decreased, and as a result of these conditions the principal operators withdrew from the field, and the valley resumed much of its old-time quietude.

Discovery of Oil at Cow Run.—The following interesting paragraph is taken from Mr. Minshall's report, to which reference already has been made:[1]

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 414.

"In the winter of 1860, Mr. John Newton, of Marietta, Ohio, was one day sitting in his office at the Harmar Bucket Factory, when his attention was called to a newspaper article on the subject of drilling wells for petroleum in Canada. In this article natural gas springs were mentioned as indications of underlying deposits of oil. Mr. Newton read the article aloud. Among the listeners was Mr. Uriah S. Dye, one of the workmen at the factory. After the reading was finished, Mr. Dye informed Mr. Newton that he had one of those gas springs on his farm at Cow Run, in Lawrence township; that the spring had been a source of curiosity for many years to the owners of the land, and that a crude attempt had been made to use the gas as fuel by a Mr. Guyton, who had a cooper shop near by. Mr. Newton was finally persuaded to go out with Mr. Dye and look at the spring. As a result of the investigation, a company was formed, composed of Jno. Newton, Douglas E. Newton, William Naylor, Moffatt Dye, and Geo. S. Bosworth. On the 2nd of February, 1861, leases were taken by the company from Uriah S. Dye, covering the W. ½ of N. W. qr. of section 19, and W. ½ of S. E. qr. of N. W. qr. of same section, in all 100 acres; also from Samuel Dye the N. E. qr. of N. W. qr of section 19, 40 acres. Drilling was commenced at once, the first well being located close to the gas-spring. The machinery then in vogue was the 'spring-pole' and 'treadle;' the motive power, human muscle. In that day it was essential that the driller be both sound in wind and limb. The first Newton well was, however, soon kicked down to what was then supposed to be a sufficient depth, and 'came in dry,' barely showing enough oil to grease the tools. Instead of being discouraged, Mr. Newton seized a shovel and said, 'Come, boys, I'll show you where to get an oil well.' He went over to the Samuel Dye 40 acres, chose a spot on the main run where the gas could be seen bubbling up through a pool, and by night had a pit dug down to the gravel. In the morning the water in this pit was covered with oil. The 'kicking process' was speedily resumed, and at a depth of 137 feet their labors were rewarded by striking a 'gusher.' The well did not flow; it was pumped with a spring-pole, and each day's product put into barrels—the pumping and filling of 50 barrels was about an average day's work for two men. The oil was taken by wagon nine miles to Marietta, and sold chiefly to Mr. William Finley, buyer for a refinery located at St. Louis, Mo."

Below is another account written by Judge L. W. Chamberlain, of Marietta and published in the Oil News, July 29, 1899:

"On February 2, 1861, John Newton, William Naylor, Moffatt Dye, George S. Bosworth and Douglas E. Newton, all of the Marietta Bucket Factory, procured a 10 year lease from Uriah S. Dye, on his farm at Cow Run, and on February 4th, same year, they took a lease of Samuel Dye (the second) on forty acres adjoining the above and proceeded on a wild cat venture to put down a well, the first in that locality.

"Oil had already been discovered at Macksburg, and what turned the attention of these men to Cow Run was a gas spring long known to the inhabitants in that locality, where gas had for years prior been utilized for heating and lighting purposes.

"The well was put down to a depth of about 160 feet, where oil was found, but the surface water was a great obstacle in the way of successful pumping. Finally a 'seed-bag' was placed on the tubing and crowded down to the proper depth to cut off the surface water, and after pumping off the water below, a fine production of oil was procured, and the Newton well was started on its successful road to fame and fortune. From this time on the development was quite rapid, and other wells were put down by the slow process of the 'spring-pole.' This was a tedious means of getting them, but two men would tramp down a few feet each day, if no bad luck interfered, and finally the rock would be reached and the reward obtained, unless the operators became discouraged and sold out for a mere pittance. One well actually changed hands three times during the drilling, and was many months getting down, the last and successful operators drilling but a few feet before striking a valuable production on an outlay of but a few dollars.

"The Newton leases were for one-fifth of the production as royalty, but afterwards the excitement ran so high that one-half was paid as royalty, the lessors to furnish barrels to haul the production. After a few years the Newton property fell into the hands of the Bergen Oil Company, a corporation from the east. This company, loaded down with many purchases in addition to this tract, finally became involved to such an extent that judgment was rendered against them in our court for about $30,000, and the property was put into the hands of a receiver, the court appointing Sheriff Hicks receiver, who proceeded to pump the old well and sell the oil until the judgment and costs were satisfied from the proceeds of this well, and the property turned back to the company. During the receivership the oil was sold at auction, and one lot sold at $15.25 per barrel at the well. No wonder that judgments could be paid and fortunes made at such prices for oil. All the world seemed to drift toward the Mecca of Cow Run then, and fabulous prices were paid for interests and the territory was cut up into small holdings. Finally leases began to expire, and the territory was bunched up into large tracts, and to-day the two largest holders are the Bergen Oil Company and the Lehmer tracts, our fellow townsman, George S. Lehmer, operating more than twenty wells. At one time there was a community of thousands at the Run, and the hungry prospector had a hard time to find rations.

"Many men were making ventures by putting in their labor and relying on borrowing or hiring tools and much borrowiing was done when the owner was not looking. Two poor fellows had been tramping the treadle all one cold winter trying to get to the sand, one with a family of half-

starved and worse clothed children, when one day they got the rock and a good showing of oil, which so excited them that the pater familias hallooed over to his wife that they could have meat for dinner that day, and I suppose a rare feast was the result. After a while Mr. C. C. Church laid a pipe-line to the river at the mouth of Bells run, Newport township, and instead of 50 cents per barrel for hauling, the pipe-line rate of 25 cents was welcomed, but prices also dropped and profits to the producer were not so great, even with cheap rates of transportation. The range of prices has been from $16 to 50 cents per barrel. Oil men are great on names and every well has its name. The Newton well came to be called the Old Cow, and then came the Heifer, the Dead Dog, Dolly Varden, Grecian Bend, Beech Tree, Willow Wells, School House well, Comet, etc.

"I doubt if we shall ever see in this county again such a jam of human beings and capital on so small a space of territory."

The production from these early wells does not appear to have been large, for according to Mr. F. W. Minshall's estimate the total yield of the field from 1861-67 was only 50,000 barrels. However, there was great expectations, and the usual excitement. Territory that was regarded as productive sold at exhorbitant rates. Here, as elsewhere, it was thought that the producing sand was limited to the valley, and not until 1869 were the adjacent hills tested. By 1865 the first boom was over, and little work was being done. Mr. Minshall's report of the field at that period is as follows:

"The Bergen Company, having suspended drilling, was pumping its ten barrels per day from the two Newton wells. The oil was bringing a good price, selling in the summer of 1865 for $14 per barrel at the wells. The company finally decided to divide its Cow Run territory into two-acre lots and sub-let them at one-third royalty. The first lease was taken by Isaac Perkins in March, 1866; three lots of two acres each were let with the understanding that he was to drill to a depth of 600 feet unless a paying well should be sooner obtained. The first well was begun soon after the lease was taken, but was not completed until the following winter. The well head is forty-eight feet below the Pomeroy coal, and 666 feet above sea level. In the Cow Run field the shales of the Lower Barren Coal Measures gave the driller a great deal of trouble by caving in and filling up the drill hole. It was found necessary to case from one to three times with sheet iron casing to shut out these caves. The tools were lost several times in the Perkins well, but were fished out again, and in November, 1866, the top of the Second Cow Run sand was struck at a depth of 595 feet. When the bit had penetrated the sand about five feet the well began to flow. It was tubed with a two-inch pipe and a seed-bag, and turned into a 250 barrel tank, which it filled in two days. The well continued to flow 100 barrels per day for several months, and kept its owners busy building tanks to hold the product, the only means of transporting the

oil to market being by wagon nine miles to Marietta, over roads which were at that time of the year almost impassable."

It is important to note that the Perkins well was the first one in this field to reach the Second Cow Run sand. It caused renewed excitement, and probably led to the period of greatest activity in the territory, when the derricks were so close together that it was difficult to drive a wagon through the valley. According to Mr. Minshall the production of the field from January, 1867, to August, 1868, was about 150,000 barrels. At first the oil was hauled to Marietta, nine miles distant; but in times of high water in the Ohio there was slack water in the Little Muskingum as far as the mouth of Cow Run, and small steamers carried coal to the latter point and took back oil. At times, when the water in the Little Muskingum became too low for steamers, flat-boats were used to float the oil to the Ohio. In 1868 a two-inch pipe line was laid to the Ohio river, about three miles below Newport, and thereafter the transportation of the oil was a comparatively easy matter.

Having now reviewed the history of the discovery of oil in the Macksburg and Cow Run fields, the development and subsequent history of these pools will be given and then the numerous other pools of the county discussed. The description of the latter will begin in the western part of the county and proceed eastward, without regard to the time of discovery and development of the territory.

DEVELOPMENT OF THE MACKSBURG FIELD.

During several years following the first boom the valley was very quiet. A number of wells were pumped, but there was little drilling. This resulted from several causes. The productive territory was thought to be limited to the valley, and since this is narrow it was soon drilled over; the price of oil had decreased until it was a fraction only of what it had been before, and besides the expense of hauling the oil to Lowell, ten miles away, was too great considering the price of oil.

The period of revival began in 1874 when George Rice secured a 150 barrel well in the 140-foot sand. This encouraged drilling, and by the close of 1877 over 30 wells had been put down in the vicinity of Macksburg. The best of these, located on the Egler tract, started at 500 barrels, but the wells were nearly all small or total failures. None appear to have gone below the 500-foot sand. The next step in the development of the field was the discovery of the Berea, and because of the importance of this Mr. Minshall's account is reproduced:

"In the summer of 1877 an attempt was made to extend the Macksburg field in a northerly direction by drilling a well for the 500-foot sand on Buffalo Run. Some years before a well had been drilled on the Slaymaker farm, on this run, which made a fair showing of oil that was supposed to come from the 500-foot sand. The well had been abandoned by

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PLATE IV

MACKSBURG AS IT IS TODAY

its owners, but the oil continued to rise through the water in the well and accumulate in the conductor, from which it was dipped and carried away in jars by the natives as a cheap lamp oil.

"The gentleman who first proposed the venture was a Mr. Williams, of Dexter City. Not having sufficient capital to carry out his plans, he made the following proposition to the writer: 'To any one who would furnish the use of the machinery, tools and casing to drill the well, he would give one-fourth of the oil obtained; machinery, tools and casing to be returned in good order, ordinary wear excepted, if no oil obtained.' Parties were found who accepted this proposition, and Mr. Williams commenced operations. The location chosen by him was on the bed of Buffalo run, Matthew Mitchell farm, which lies just below the Slaymaker tract. Mr. Williams was afterward joined by Captain Mosely, and the well was sunk by them to a depth of 800 feet without obtaing oil in paying quantity. These particulars are given at some length because this is the well by which existence of the 'Berea' sand in the Macksburg field was proven. After Messrs. Williams and Mosely had abandoned the well, the parties who owned the machinery and tools were persuaded by the writer to drill it down in search of the 'Berea,' which was then yielding oil in the White Oak district of West Virginia. Careful measurements of the intervals between the Ames or crinoidal limestone and the 'Berea' had been made in the West Virginia field, where it was found to be about 1,400 feet. The position of the Ames at Buffalo Run was known by him to be about 70 feet below the bed of the river on the Mitchell farm. It was, therefore, decided to drill the well to a depth of 1,500 feet, if the rock should not be found at a less depth. The interval at Macksburg proved it to be somewhat less than at White Oak, and the top of the sand was struck at 1,427 feet. The well was drilled wet and was standing full of salt-water; when the first bit was run in the sand it began to show gas, and the second bit developed enough gas to throw the brine over the top of the derrick and empty the well. In order to complete the well it was necessary to place an oil saver upon the casing-head to prevent the driller being pickled. Below the gas a thickness of 15 feet of very fine white sand, containing the rainbow colors of petroleum was found. The well was tubed with packer and two-inch pipe, but yielded nothing but dry gas. It was never torpedoed. The odor of the gas was exactly like that of petroleum, but this and the colors were the only evidence of the propinquity of this venture to the richest portion of the Macksburg field."

The first producing well near Macksburg in the Berea sand was secured in 1879 by George Rice. Besides sufficient gas to pump the shallow wells, it flowed 15 barrels of oil per day. The third Berea well was started in 1881 on the Lund farm. It produced much gas, but no oil. In 1882 three wells were drilled—one each on the William Dearth, A. Perkins and William Atkinson farms. All were small oil wells. In 1883 a well was

drilled on the Ohio Coal Company's lands which started at 100 barrels. This was the first of the large Berea producers, and at once led to extensive operations.

The Second Stage in the Development of the Field.—One of the results of the discovery of oil in the Berea was the testing of the territory outside of the valley. The demonstration that oil existed beneath the hills greatly extended the possibilities of the field. After the completion of the 100-barrel well referred to above, others were drilled in rapid succession, the tools moving in all directions until 1885, when the limits of the field had been determined. This extended almost as far north as Dexter City, as far south as Elba, two and one-half miles east of Macksburg, while the western boundary was practically limited by Duck creek.

The largest producers were secured on the George Dyer farm, one and one-quarter miles northeast of Macksburg in section 5 of Jefferson township, Noble county. Two wells on this place, drilled in 1885-6, are reported to have started each at 400 barrels, but the great body of Berea wells in the field started at from 15 to 60 barrels. All contained sufficient gas to flow the oil, thus diminishing the expense of operating them.

As has been previously stated, one of the early difficulties was the transportation of the oil, and as the production of the field increased the problem became more serious.

The completion of the Cleveland & Marietta railroad gave temporary relief, for in 1883 a pipe line was connected with it, the oil being transported in tank cars. A year later a line was laid to the Muskingum river, near Lowell, and the oil loaded on boats. In 1885 the National Transit laid a three-inch line to Parkersburg, West Virginia, and from that time the transportation of the oil has been a comparatively easy problem.

The Berea wells were drilled wet, the casing usually extending to about 65 feet below the 140-foot sand, but occasionally it went to the 300-foot. The object of the casing was merely to prevent caving, and not as at present to exclude water also. When drilled the salt-water was kept from the oil rock by placing a packer around the tubing a few feet above the sand. This could not subsequently be removed, since the salt-water above would at once enter the sand and cause a deposit of paraffine around the hole, thus shutting out the oil. Hence, when sand obstructed the holes in the bottom of the tubing, or the pores in the rock in any manner became closed, the production of the well ceased though the oil had not been exhausted. This was very unfortunate, since it has made necessary the re-drilling, at a great expense, of the entire Berea producing territory.

The production of the field increased rapidly as well after well was drilled. In August, 1884, it was 4,600 barrels; in December, 1884, 10,000 barrels; in March, 1885, 21,600 barrels; in July, 1885, 79,700 barrels. From that time there was a decrease, the output having been 66,175 in December, 1885, and 57,700 barrels in February, 1886.

As a rule these wells were long lived, and several are still producing. According to Mr. C. G. Dutton, of Elba, one is found on the Walter farm; another on the Coal lands, and a third on the A. Morris tract.

Development of the 500-Foot Sand.—Drilling for the Berea led to another result of great importance viz., the discovery over considerable areas of valuable deposits of oil in the 500-foot sand. According to Mr. Minshall the first producing well in this sand was drilled on the Atkinson farm, just below Macksburg, in 1865,[1] but others give earlier dates. Thus Mr. Orton Dunn, of Dexter City, states that a well drilled on the Keith farm in 1861 struck the sand in question at a depth of 448 feet, and that the well produced 100 barrels of oil the first day. Mr. Dunn also states that the well continued producing until 1899, when it was abandoned. Mr. Frank Ayers, of Macksburg, informed the writer that in 1863 a well was begun on the land of the Lowell Oil Company near Macksburg, and reached the 500-foot sand the following year. It is claimed that this well has produced continuously from that time, except during short intervals when it was closed for repairs. At present it yields about one and one-half barrels per day. Mr. Minshall's familiarity with the field, however, gives his statement much weight. All agree, however, that active work in the sand did not begin until 1865, and even then on a comparatively small scale. In 1866, 1878, 1888 and 1890, wells were drilled to the 500-foot sand on the Keith (now J. S. Dunn) farm. All made some oil, and it is difficult to understand why drilling on this tract did not become active until 1890. In the latter year there were 16 producing wells on this farm, consisting of 72 acres. The northern part of the Macksburg field, in so far as it relates to the 500-foot sand, is confined to sections 11 and 12 of Jackson township, and 5, 6, 8 and 32 of Jefferson township, Noble county. During the past ten years work in this sand has been active, and it appears from the dry holes that the limits of this part of the field have been pretty definitely determined. In one only of these sections, viz., 6 of Jefferson township, are wells found in both the 500-foot sand and the Berea.

South from Macksburg active work in the 500-foot sand began about 1885, and is still in operation (1902). The territory includes sections 24, 25 and 36 of Jackson township, Noble county, 7, 17, 18, 19, 29 and 30 of Aurelius township, Washington county, and a strip one-half mile wide and one and one-quarter miles in length along the line of junction of Adams and Salem townships, Washington county. Many of the wells in the southern part of the field have been abandoned. Thus, on the J. Gessel farm of 103 acres, one mile west from Macksburg, 14 wells have been drilled, 11 of which were producers, but 7 of these have now (1900) been abandoned. The combined production of the four is ten barrels per day.

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 450.

The best well on the farm strted at 140 barrels per day On the S. Gessel farm, lying immediately south of the one just mentioned, there were formerly nine producres, but all have been abandoned. The largest well in this part of the field was reported on the Isaac Reed farm, in section 36 of Jackson township, Noble county. Its initial production was 200 barrels daily, and it is said to have kept up this rate for a month. Early in the history of the field the wells yielded sufficient gas to supply the boilers for pumping, but in many places the flow has become so weak that coal is now used. The points just given concerning these three farms apply almost equally well to any others in this part of the territory.

The pool lying along the line adjoining Adams and Salem townships, Washington county, is at present separate from the territory northward, and is commonly known as the Lowell field. It was discovered late in the summer of 1898, and drilling has been active since that time. The principal farms are the Minsch, Dovenbefger and Rausch. Of these the first named is the best, there being 22 oil and 1 gas wells on it in September, 1900. The production of oil on this farm was 150 barrels per day at that time. The gas well had an initial rock pressure of 400 pounds, but had not been used for purposes other than those on the lease. Seven wells had been drilled on the Rausch farm, which joins the Minsch on the south, at the time mentioned. Of these six were producers, the combined output of which did not exceed 40 barrels per day. The Dovenberger farm joins the Minsch on the north. Of the 11 wells drilled on that place 6 were producing, three were dry and 2 were abandoned. These wells then made approximately 180 barrels per week. In 1901 the pool was extended by the discovery of oil on the Fauss farm, lying to the south. A well drilled on the Wunderlick farm about July 1, 1901, started at 240 barrels per day, and a year later was still flowing 25 barrels. Fourteen wells, all producers, have been drilled on the Spies farm of less than 50 acres, the best one having an initial production of 125 barrels. The development of this territory makes practically a continuous strip from Macksburg to the Muskingum river near Lowell.

Development of the 140-Foot Sand.—Besides the Berea and Macksburg 500-foot sands which have now been discussed, there is still another important producer in the field, viz., the Macksburg 140-foot sand, which as has been previously stated appears to be equivalent to the First Cow Run. This territory lies south of Duck creek, in Aurelius township, Washington county, and includes sections 17, 21, 28 and 29. One of the best farms, owned by W. R. Wickens, in the last named section, contained in 1900, six wells in the 500-foot, and perhaps 20 in the 140-foot sand. The first and best of these shallow wells was drilled about 1885, and started at 180 barrels per day. This included, however, not only the production of the 140-foot sand, but also that

of a "stray" lying 40 feet higher. One of the wells on this place, having its surface two feet below the Meigs Creek coal, struck the 140-foot sand at 380 feet, making the interval between the two, 382 feet. Another well, about 200 yards from this, started two feet above the coal and found the 500-foot sand at a depth of 724 feet. Occasionally these wells flow when first drilled, but as a rule they have to be pumped from the start. Oil taken from a tank connected with the 140-foot wells had a gravity of 40 degrees B. The Shimmel farm, comprising 300 acres, is another important one. The best well, drilled in 1888, started at 180 barrels, but the greater number had an initial production ranging from 4 to 60 barrels daily. The number of holes drilled on this tract is large, and according to the proprietor not less than 30 have been failures. Other farms in this part of the field merely duplicate what has been said, and so will not be mentioned.

Other Sands.—Besides the three sands discussed there are others which furnish a little oil. Just west of Macksburg, on the east bank of Duck creek, are three wells in a shallow sand. These were drilled in the spring of 1898, and have depths of 68, 70 and 72 feet. They began producing from 1 to 3 barrels daily, but have decreased so that they are no longer pumped regularly (1901). The oil is said to have a gravity of 28 degrees B., and is sold in the vicinity at 20 cents per gallon for lubricating purposes. This sand is of interest because it is the same as that in which oil was discovered in 1860. Along Buell's run, one mile southwest of Elba, is a sand which is reported to lie from 15 to 35 feet below the 140-foot. It is said to have been first struck in 1888 on the land of Thomas Marshall, in the southwest corner of section 21. This well started at 100 barrels Some experienced drillers, however, regard this sand as the 140-foot. West of Warner a number of small wells have been secured in the Schramm sand, which lies about 140 feet below the Macksburg 500. This sand, which was discovered about 12 years ago, has never been an important producer.

The Third Stage in the Development of the Field.—The method of drilling, casing and tubing the early Berea wells has already been stated, and it has been shown how these failed to secure all the oil in the sand. Unfortunately this necessitated re-drilling the Berea territory at a great expense, and this is here considered the third stage in the development of the field. The first of these "second crop" wells as they are called, is reported by C. G. Dutton, of Elba, to have been drilled about 1895 by George T. McDonald on the old Phelps farm, two miles east from Macksburg. This well started at 75 barrels and in 1900 was producing five. It seems probable, however, that the start of the re-drilling was earlier, and O. C. Williams, of Macksburg, reports that the first well was drilled on the Atkinson farm about 1890, and in view of the large number of wells now drilled this date seems the more probable.

The wells are drilled dry, i. e. the water is excluded by casing which extends through the Salt sand. The territory has not been completely drilled over, but is approaching that state, and the number of wells is said to be as great as when the territory was drilled the first time. As might be surmised, the wells are smaller than those drilled in the eighties. The great body started at from 4 to 50 barrels, while formerly their initial production ranged from 10 to 400. The first drilling exhausted the gas, so that while the wells then flowed, they now have to be pumped.

This field is cited by those who believe that oil is now being produced in the earth's interior as corroborating that view. As a matter of fact it proves no such thing. The oil now being secured in the Berea was there when the territory was drilled the first time. The re-drilling is merely a result of the unfortunate methods in vogue a decade ago, and it is safe to say that when the existing Berea wells cease to produce, the life of the field will end.

Geology of the Field.— The surface rocks lie principally in the Monongahela formation or the Upper Productive Coal Measures. The Pittsburg coal, which here is little more than a black streak, is shown in nearly every hill. The limestone overlying it is more conspicuous. The Meigs Creek or as it is locally known the Macksburg coal, however, which lies about 80 feet above the seam previously named is important. It supplies the surrouning country with fuel, and was formerly mined at Macksburg for railroad shipment. Topographically considered the country is one of the most rugged parts of the state. The succession underground is shown by the following well records:

Dunn well No. 6, northeast quarter section 12, Jackson township, Noble county. Completed March, 1891. Log furnished Survey by Orton Dunn. Surface of the well six feet below the Meigs Creek coal.

	Thickness of stratum. Feet.	Total thickness. Feet.
Unrecorded	285	285
Ames limestone	1	286
Unrecorded	99	385
140-*Foot sand*	5	390
Coal	1	391
Red rock	20	411
Cambridge limestone (Rucker lime)	4	415
Slate	39	454
Limestone (case through)	8	460
Pale Green slate	35	495
Black slate	35	530
Dunkard sand	95	625
Coal	4	629

	Thickness of stratum. Feet.	Total thickness. Feet.
Slate	15	644
Peaker sand	25	669
Coal	1	670
Slate	32	702
500-*Foot sand*	22	724
Coal	3½	727½
Slate	20	747½

The interval between the Ames limestone and the 140-foot or First Cow Run sand is a little larger than that found farther west in Morgan county, and the same is true with reference to this sand and the underlying Cambridge limestone.

The following log of George Rice well No. 18, at Macksburg, is taken from Prof. White's report:[1]

		Thickness of stratum. Feet.	Total thickness. Feet.
Conductor		10	10
Coal, Macksburg, (Meigs Creek)		5	15
Soapstone		8	23
Sandy shale		117	140
Limestone, blue		13	153
Slate, blue		10	163
Limestone, blue		12	175
Slate, blue		45	220
Red "cave"	red rock..... 10 feet blue slate..... 7 feet red slate..... 18 feet	35	255
Slate, blue		15	270
Slate, red		7	277
Slate, blue		38	315
Limestone, blue		28	343
Sand ("140-*foot sand*" "*First Cow Run*")		35	378
Slate, blue		32	410
Slate, black		10	420
Slate, blue		5	425
Slate, red		27	452
Slate, blue (cased)		4	456
Limestone		14	470
Slate		72	542
Limestone (water)		12	554
Sand ("300-*foot sand, Dunkard*")		78	632
Slate		53	685
Sand (500-*foot sand*)		17	702
Slate		39	741
Sand		9	750
Limestone		25	775

[1] *West Va. Geol. Sur.* Vol. 1, p. 298.

	Thickness of stratum. Feet.	Total thickness. Feet.
Sand, pebbly (800-foot sand)	51	826
Slate	79	905
"Salt sand" — Sand, hard 68 ft.; Slate, black 54 ft.; Sandstone, hard white 68 ft.	190	1,095
Slate, dark	21	1,116
Sand, dark, pebbly (Salt-sand and "Big Injun")	214	1,330
Slate, light, black at bottom	293	1,623
Slate, black	11	1,634
Shells and black slate	44	1,678
Macksburg (Berea) oil rock	17	1,695

Commenting on this record Professor White says: "The sand at 1,116 feet is the one which was always known as the 'Salt sand' by the Macksburg operators, but its upper half only belongs in the West Virginia operators 'Salt sand,' while its lower half is the Big Injun, the Mountain limestone usually separating them, having thinned away and permitted the two distinct formations to combine practically into one rock.

"Whether the sand at 685 feet or that at 775 represents the 'Second Cow Run is not known certainly, but more probably the latter."

If Professor White is correct in the opinion expressed in the last paragraph, the 500-foot sand and the Second Cow Run are not equivalent, but the latter lies 90 feet below the former. It will be noted that he regards the 800-foot sand as more probably the equivalent of the Second Cow Run. The interval between the First and Second Cow Run sands at Cow Run, where the deeper sand was named, is 400 feet. That at Macksburg, between the 140-foot or First Cow Run and the 500-foot sands is but little more than 300 feet, while that between the 140-foot and the 800-foot sands is almost 400 feet. These relations support Professor White's claims.

The Macksburg oil field is located on an anticline. On one side the strata dip rapidly westward, and the Meigs Creek coal seam, which at the village of Macksburg lies 200 feet above the valley, is found at water level along the Muskingum where it has long been mined. The point at which the coal reaches its highest altitude has not been determined, but it must be near Macksburg. To the east the dip is apparently smaller than to the west, so that for a distance of ten miles in Salem and Liberty townships the coal is well above drainage, and is mined for local consumption. In fact the limestone or Pittsburg coal which lies about 80 feet below the Meigs Creek is found at a number of points above drainage in Liberty township, and as far east as Flint's Mills, Ludlow township.

The Oil Sands.—Few oil fields have the number of producing sands that this one has. However, the greater number of them have been of little

importance. The succession is as follows in the valley of Duck Creek at Macksburg:

1. Shallow Oil sand (First sand worked).
2. 140-foot or First Cow Run sand.
3. Buell Run sand.
4. 300-foot sand = (?) Dunkard.
5. Peaker sand.
6. 500-foot sand.
7. Schramm sand = (?) 700-foot.
8. 800-foot sand = Second Cow Run.
9. Berea or Macksburg sand.

Sand No. 1 is of historic interest, since it was in this that the first oil was found in 1860. The formation is quite thin—5 to 6 feet—in the few wells in which it produces at present. It seems never to have produced beyond the valley of Duck Creek, and might well be termed a "stray", to use the suggestive name of the driller.

Sand No. 2, or the 140-foot, is one of the best in the field. It was discovered very early and has been producing continuously, or nearly so, ever since. Its position is about 330 feet below the Macksburg or Meigs Creek coal, and nearly 100 feet below the Ames limestone.

Sand No. 3, or the Buell Run, is of very little interest, and is found on a few farms only, as has already been stated. In fact it may properly be classed with the "strays."

Sand No. 4, or the 300-foot sand, is also of little interest. It has never been an important source of oil in this field. The sand may be the equivalent of the Dunkard of West Virginia.

Sand No. 5, or the Peaker, has yielded some oil in and around Macksburg. The first well in it was drilled on the Peaker lot, Macksburg, in 1877. It is said to have started at 40 barrels and to have produced 16 barrels per day for three months, and then decreased until 1879, when it was abandoned.

Sand No. 6, or the 500-foot, is one of the three important producers of the field. It lies about 730 feet below the Meigs Creek coal, and has a thickness that usually ranges from 10 to 30 feet in the producing territory. Normally it is a soft, porous sandstone, but sometimes runs into a conglomerate. It is more continuous in this field than the 140-foot sand, but occasionally disappears, its place being occupied by shales. As an oil producer it is long lived, but it cannot be said to surpass the 140-foot sand in this respect.

Sands No. 7 and 8 never have been, nor are they now, important producers. Many years ago they yielded some oil in the valley of Duck Creek, but were long unproductive until the Schramm sand was found near War-

ner about 12 years ago. The position of this corresponds closely with that of the 700-foot, and the two appear to be equivalent. Both Nos. 7 and 8 are ordinarily unrecognized by the driller. They appear to have a small area, and may properly be classed with the "strays."

The next and lowest of the sands in this field is the Berea, and it is the best known and most valuable sandstone stratum in the state. It underlies the entire eastern half of the state, and its character has been shown by the hundreds of wells drilled to it. Nowhere is it better known than in southeastern Ohio. It lies from 1,665 to 1,675 feet below the Meigs Creek coal, but eastward the interval appears to increase, being 1,688 feet on the old Phelps farm, two miles from the village. At Macksburg the sand in the valley is struck at a depth of 1,460 feet, but at Elba, two miles southeast, it is found at about 1,550 feet, indicating a strong dip in that direction. The sand ranges in thickness ordinarily from 7 to 25 feet, the average being perhaps 17 feet. Normally it is finer than the shallow sands, and is much more continuous. Rarely, in fact, does it disappear, and this character makes it a landmark among drillers.

DEVELOPMENT OF THE COW RUN FIELD.

Operations in this field, after the period of earliest development, were much less extensive than at Macksburg. The territory was never greatly extended beyond the narrow valley of Cow Run, and in 1900 the producing area was confined to the southern half of sections 14 and 20 and the northern half of sections 13 and 19 of Lawrence township. The territory almost joins the Newell's run field, and the two might be considered as one; nevertheless, because of the historic interest of the former, and as a matter of convenience, the two will be discussed separately.

The drilling of the Perkins well to the Second Cow Run sand in 1866 was of great importance, since it demonstrated the existence of a reservoir of oil in a deeper sand, thus increasing the production and extending the life of the field. This may be regarded the second stage in the development. The success of the Perkins well again filled the valley with excitement, and the scenes resembled those of a few years before. Another discovery of importance was made in 1869 when it was found that oil existed under the hills as well as the valley. This may be regarded as the third stage in the development of the field. From that year wells have been drilled from time to time until the present, and doubtless others will be occasionally drilled in the future.

The production down to 1885 is reported by Mr. Minshall as follows:

	Barrels.
1861-1867 estimated	50,000
1867-1868 (August)	150,000
1868-1869 West Va. Transportation Runs	89,571
1870 West Va. Transportation Runs	110,412
1871 " " " "	46,543

		Barrels.
1872	" " " "	39,456
1873	" " " "	35,016
1874	" " " "	31,990
1875	" " " "	26,606
1876	" " " "	20,427
1877	" " " "	21,461
1878	" " " "	22,929
1879	" " " "	22,370
1880	" " " "	20,655
1881	" " " "	16,994
1882	" " " "	12,682
1883	" " " "	14,166
1884	" " " "	8,291
1885	Ohio Transit Co.....	12,000
Total	.....	751,519

Mr. Daniel Ward, who has resided in the territory since 1868, reports that the spring-pole method of drilling had been abandoned when he entered the valley. This crude plan was followed by the steam engine, which at first operated a string of tools weighing between 300 and 400 pounds, constituting a marked advance over the preceding method, but was slow in comparison with the present. A depth of 300 feet might be reached in 30 days, and with good luck the Second Cow Run sand might be struck in 40. There was usually but little trouble from water, but much from caving. This was prevented by casing the wells, the material being sheet-iron, of which the joints fitted together like stove-pipe. The worst cave was found in red shales lying above the first sand, and is probably the "Big red," which has already been referred to several times in this report.

There were formerly several famous wells in this field, but nearly all have long been abandoned. The following letter written by Judge L. W. Chamberlain, of Marietta, and published in the Marietta Register, June 15, 1899, discusses the School House well, perhaps the most interesting one of those now producing on Cow Run:

"There has been much written and printed recently in regard to early oil developments in Ohio and as might be expected, the writers have been at fault frequently in their statements. Recently quite a great deal has been written in regard to the School House well at Cow Run in this county. The history of that well is about as follows:

"In the summer of 1869 Moffit Dye and several others leased of the school board of Lawrence township about one-fourth of an acre owned on Cow Run and occupied by a hewed log school house, situated within 20 feet of the Run.

"Wells had been drilled all around the old school house, and the leasers proceeded to put down a well in front of the door of the old academy, and on the 21st day of October, 1869, the drill broke into a crevice at a depth of

594 feet, and gas and oil immediately came to the surface and drove the drillers out of the derrick. In that early period few wells about the Run had been cased with artesian casing and this was one of the few. The well continued to flow for about one year, during which time it had put out about $63,000 worth of oil which had to be hauled to market, the school board securing one-third of this as royalty. At the end of one year the well was pumped and has continued to produce ever since, now nearly thirty years. The production ran down for many, but for several years has produced the same for each year. Until recently the well has been pumped by steam, but during the past year has been fitted up with a gas engine which is being run by the gas from the well and plenty to spare. The old casing is still doing duty in the well, and the well promises to yield for many years to come. Modern oil men claim, some of them, that there is no such thing as a crevice well, but there can be no doubt about this one being just what the drillers pronounced it in the start, a genuine crevice of about one foot opening. The well was never shot and has never required cleaning out.

"There are other wells on the Run that are older than this that are producing to-day."

According to Judge Chamberlain the well produced three barrels per day in 1900. It seems neither to increase nor decrease. The royalty from the well goes to the general educational fund of the township, and for years more than met expenses, the surplus being loaned. The royalty is a graded one depending on the production of the well; at first it was one-third, then one-fourth, and at present one-eighth.

The following companies were operating on Cow Run in 1900:

Exchange Oil Company
Bergen Oil Company
William Reeder
Ward & Campbell
Gilbert & Davis.

The Exchange Oil Company owns 501 acres and has long been active in the field. It had 28 producing wells which were about equally divided between the First and Second Cow Run sands. The wells were very small, making about 350 barrels per month. They were pumped every other day, and then only 3 hours.

The Bergen Oil Company had 10 wells, 4 of which were in the First and 6 in the Second sand. These made about 150 barrels per month. It is seen from this that the wells are all small. They were pumped for a short time each morning and evening.

The other companies named were very small producers. William Reeder had 5 wells, Gilbert and Davis 5 or 6, and Ward and Campbell 4, the latter's making perhaps 75 barrels per month.

In the summer of 1902 the property of the Exchange Oil Company was divided into 4 parts, and three of these were leased respectively to the Boston Oil Company, William Reeder and John Gray. In August the drill was once more put to work and it was expected that 30 wells would be drilled before the close of the year. The first wells were all small producers. They were located on the hill sides facing Cow Run and went to the First sand. These wells are located in territory that was once drilled. Not improbably the Second sand also will be tested, and it may be that the floor of the valley itself will be drilled over. Before this work began there were 26 wells making conjointly 9 barrels per day on the property.

From what has been said it is apparent that the field at present is of little importance. It will doubtless be a small producer for many years, but interest will center in its past record.

Geology of the Field.—The surface formations lie in the Conemaugh, Monongahela and Dunkard series. Topographically the territory is very rugged. Fortunately three coal seams, The Hobson, Meigs Creek and Pomeroy, with their associated rocks, are all above drainage, and consequently it is easy to determine the structure of the region. This has long been known. It was discussed by Andrews in Volume II, pages 493-99, of the Ohio Survey, published in 1874, and by F. W. Minshall in Volume VI, Chapter VI, published in 1888. Since, however, neither of these volumes may be accessible to the reader, the essential points are reviewed here.

The Cow Run oil field lies on one of the greatest arches found in Ohio. In the central part of the field the Meigs Creek coal lies 245 feet above the bed of Cow Run, and the Pomeroy seam, 153 feet. Following these west along Cow Run, the Pomeroy coal falls below drainage in less than one-half mile, and the Meigs Creek in about one and one-half miles, just below the point at which Cow Run unites with the Little Muskingum. Going east from the centre of the oil pool, the strata, as shown by the coal beds, drop more than 200 feet in 2 miles. The same relations are found in going north and south from the centre of the uplift. Hence the strata make a dome from the centre of which the rocks dip in all directions.

The formations in the hills along Cow Run have been measured by Andrews and are here reproduced.[1]

	Feet.	Inches.
Yellow shale	25	00
Coal, Hobson seam	1	4
Clay	0	4
Coal	0	8
Clay	1	0
Black bituminous slate	0	10
Coal	0	1

[1] *Geol. Sur. of Ohio*, Vol. II, p. 496.

	Feet.	Inches.
Clay	0	3
Limestone	4	00
Not exposed	18	00
Heavy sandrock	60	00
Shale	10	00
Coal, "Sandstone" or Cumberland seam (not measured).		
Not exposed	75	00
Blue limestone	4	00
Buff limestone	2	00
Limestones and shales	10	00
Coal, Pomeroy seam (not measured).		
Not exposed	98	00
Blue limestone	5	00
Not exposed	40	00
Bed of Cow Run.		

The sandstone or Cumberland coal is what has already been referred to several times as the Meigs Creek.

The underground succession is shown by the following record of Centennial well No. 6, drilled in 1896, and located east of the centre of the uplift on property of the Exchange Oil Company. Data furnished by Mr. George Lehmer, Marietta, Ohio:

	Thickness of stratum. Feet.	Total depth. Feet.
Conductor	11	11
Pittsburg (Pomeroy) Coal	1	12
Calcareous shale	9	21
Lime	10	31
Red soapstone	5	36
Red shale	8	44
White shale	42	86
Lime	10	96
Mixed shale	5	101
Shale and water	19	120
Red shale	10	130
Sand	5	135
White shale	20	155
Red shale	22	177
White shale	23	200
Sand	3	203
Red rock	32	235
Sand	11	246
White slate	40	286
Sand	4	290
Sand	4	294
Coal, smut rock	1	295
White slate	4	299
Lime	8	307
Gray shale	2	309

	Thickness of stratum. Feet.	Total depth. Feet.
Lime	9	314
Fire clay	4	318
Lime	7	325
First Cow Run Sand	47	372
Red rock	23	395
White shale	46	441
Dark shale	50	491
Sand	10	501
White shale	14	515
Pale red shale, very hard	64	579
Lime	5	584
Sand	10	594
Black shale	16	610
White shale	30	640
Sand	10	650
Coal	1	651
Sand	39	690
Dark shale	5	695
Sand, gas	7	702
White shale	11	713
Coal, smut rock	1	714
Fire clay	20	734
Sand	2	736
Sandy shale	6	742
Black shale	4	746
Slate, black	30	776
Second Cow Run Sand	64	840
Black slate	3	843
Black slate	97	940
Sand	83	1,023
Dark shale	57	1,080
Sand	12	1,092
Black shale	53	1,145
Salt sand (no water)	9	1,154
Light shale	6	1,160
Black shale	23	1,183
Big Injun sand	2	1,185
Dark shale	39	1,224
Sand	2	1,226
Dark shale	7	1,233
Sand	7	1,240
Sandy shale, hard	22	1,262
Dark shale, hard	63	1,325
Dark shale, softer	20	1,345
Dark shale	20	1,365
Dark shale, hard	10	1,375

At this depth the well was abandoned because the hole had become crooked.

The thin seam of coal found 12 feet below the surface is the Pittsburg. The interval between it and the First Cow Run sand is 313 feet, while at Macksburg it is 328 feet. At Macksburg the Salt-sand lies 527 feet below the 140-foot sand, while at Cow Run the interval as shown in the above record is 820 feet. If the sands here are correctly named it shows a rapid thickening of the section to the southeast. However, the stratum called Salt-sand is insignificant in comparison with that found at Macksburg, and it is quite certain that the heavy sand struck at 940 feet is the sand in question. This would make the interval 568 feet.

The Oil Sands.—As has already been said there are two producing sands, the interval between the two being about 400 feet. The upper or First sand frequently has à thickness ranging from 30 to 35 feet. The top is fine and hard, and hence contains little oil. Immediately below, the rock is coarser and softer and here the oil is found. Generally a few feet of limestone are reported above the oil rock, but examination of the material shows it to be a sand. The lower or Second sand is thicker than the upper one, ranging frequently from 40 to 60 feet, but figures above and below these are found. Sometimes the sand is divided by from 6 to 8 feet of slate, in which case the oil is found below the break. Generally the top of the rock is fine and hard, and frequently the pay lies immediately below. Outside of Cow run this formation is not easily recognized, and almost any sand lying from 100 to 500 feet below the First is called the Second by the driller.

OTHER WELLS IN LAWRENCE TOWNSHIP.

As might be expected the success along Cow run stimulated the driller in his search for oil in the surrounding territory, and as a result wells were drilled by the scores. While a small well has been found occasionally, the results have not compensated the operator for his time and money.

In the northeast corner of the township in section 6, several shallow wells have been drilled; of these 3 were dry and 2 produced some gas, but are now abandoned. In section 5, immediately to the south, 2 wells are reported—a dry hole in the northeast quarter and a small producer near the middle of the section. One failure is reported in the northwest corner of section 4.

On section 12, which joins 6 on the west, a half-dozen wells have been drilled, but since these belong to the small pool around Fifteen P. O. they will be considered in that connection. Three dry holes have been drilled in the southeast corner of section 18, which joins 12 on the west. Along the streams in sections 16, 17 and 23 probably two scores of wells have been drilled. A few small producers have been secured, enough to encourage the driller. Two of these wells were deep, one on the Rathbone farm 1650, and the other on the Britton 1800 feet. By far the

greater number went no deeper than the First Cow Run sand. In the northeast corner of section 2, two dry holes have been drilled. Farther south many dry holes and a few producers have been drilled along the valleys of the Little Muskingum and tributary streams in sections 15, 21, 27, 20, 26 and 25. Nearly all of these are in the First Cow Run sand, but occasionally a deeper one was drilled. Thus in the southeast corner of section 26 one reached a depth approximating 1700 feet. Along the eastern line of section 2 several wells have been drilled, but these form a part of the Bosworth pool, and will be considered in that connection. On section 1, three dry holes have been drilled along the north line, and 2 dry holes and 1 producer near the south line. In section 13 many wells have been sunk, but these are part of the Newell's Run field and will be considered when that pool is discussed. Three dry holes and 1 producer have been drilled on the southern half of section 19.

WELLS IN THE WESTERN HALF OF WASHINGTON COUNTY.

Having now considered the Macksburg and Cow Run fields, the western half of the county will be reviewed. Hereafter the pools will be taken up with reference to their geographical position, and independent of the time of their development.

Palmer Township.—Lying in the northwestern corner of this township there is part of one of the most valuable pools in this part of the state. It includes the territory near Brown's Mills and constitutes the eastern part of the Chester Hill field. Since this has already been considered in the chapter on Morgan county it will not be further noticed here. In the southeastern corner of this township and the adjacent part of Barlow a number of gas wells have been secured. The sand is shallow, though reported deeper than the First Cow Run. It is said that gas was formerly piped from this field. In 1902 one well was used for lease purposes and the others supplied farmers.

Barlow Township.—Besides the gas wells referred to above three pools of oil have recently been discovered. These all lie along the northern border of the township. The most promising territory is occupied by the Fisher farms on which oil was first secured in August, 1901. A year later 30 wells, 14 of which were producers, had been drilled in that vicinity. Not until the 12th well had been drilled was a good producer secured. This had an initial production of fifty barrels the first 24 hours, and made 35 barrels per day for some time. The best well is reported to have had an initial production of 125 barrels. The sand is the First Cow Run and its record in other fields for treachery is fully maintained here.

One mile southwest from the Fisher farm a pool has been opened on the Lynch tract. In August, 1902, only 4 wells had been drilled and one of these was dry. In the northwestern corner of the township a small pool has been secured. The wells are on the Woodruff, Arnold and Beck-

enridge farms. Like the preceding pool, however, sufficient work had not been done when the territory was visited to indicate the size of the field. The sand is the First Cow Run. Outside of these pools many wells have been drilled. Near Vincent several gas wells have been secured which supply the village with fuel. Several small oil wells also have been found in that vicinity. No considerable area remains untested, and yet small pools may still be found.

THE MOORE'S JUNCTION OIL FIELD.

Location and Area.—The principal part of this pool lies in the immediate vicinity of Moore's Junction, 3 miles southwest of Marietta. It extends directly out to the Ohio river, across which it is continued in West Virginia. It has a length of one and one-half miles parallel to the river, and a maximum extension at right angles to this of 1 mile. From the western side of this a narrow strip starts north 32 degrees west (as run by a surveyor) and extends without a break past Tunnel station to Turkey Hen creek in the northwest corner of Warren township. In fact about 2 miles beyond this, near the southern line of Watertown township on the Potmyer and adjacent farms, a few small producers have been secured, which may be a continuation of the narrow strip just referred to. Throughout parts of this the productive strip is so narrow that one row only of wells is drilled.

Discovery and Development.—The anticline which crosses the river at Moore's Junction has long been known. Because of its presence the late Dr. Edward Orton predicted that oil or gas would be found in that vicinity. This was before any wells had been drilled.

According to Colonel Moore, who owns the most valuable part of the pool, the first well was drilled in June, 1894, and was located on his farm along Chapin run, a short distance from the river. At a depth of 1130 feet a small amount of oil was secured, and as a result of this encouragement two additional wells were drilled the same year. However, the production was so small that the operators were not willing to make further tests, and it was not until 1898 that another well was drilled. This too, was a failure, but at about that time oil was found across the river, and this made certain further explorations on the Ohio side. The next well on the Moore farm started at 150 barrels per day, and at about the same time Barnsdale and Ranger who held the lease on the Wittekind farm, adjoining Moore's, struck the sand and were rewarded with an 80 barrel production.

A little later a well was drilled along the line of the Moore farm, close to the Wittekind well. It flowed 500 barrels the first 24 hours, but ruined the Wittekind, which at once dropped from 80 to 40 barrels, and decreased so rapidly that it was soon abandoned. From that time work has been continued on the Moore farm until at present (August, 1902) the rigging is up for the 65th well.

The second well on the Wittekind was drilled in November, 1898. It was small, starting at 20 barrels, but decreased rapidly and in July, 1900, was making about 1 barrel per day. Two additional wells were drilled on this farm the same fall, and one of these, No. 4, which was completed December 14th, flowed 37 barrels the first 30 minutes, and 74 barrels per hour during the following 48 hours. Then it flowed 60 barrels per hour for an equal length of time. Two weeks after completion it produced 300 barrels per day. The flow gradually diminished and by March, 1899, was 200 barrels per day. At that time another well was drilled about 300 feet northwest and the production in No. 4 dropped to 100 barrels. From that time the yield has steadily diminished, and in August, 1900, was only 10 barrels each 24 hours. Doubtless it is now still less.

Well No. 9 on the Wittekind farm was completed in April, 1899, and flowed 240 barrels the first 24 hours; it dropped to 120 barrels the second day, and the third day ceased flowing entirely, though some gas was given off. Later the well was pumped and produced from 4 to 5 barrels per day, a rate that was continued as late as August, 1900. In all 19 wells had been drilled on this farm of 148 acres at the date just mentioned; seven of these were producing oil, about 50 barrels in all per day; and one gas enough for the boiler which supplies the power necessary for pumping the wells. The farm was being operated by the United States Oil Company, which purchased it from Barnsdale and Ranger for a large sum. The producing sand was reported to be the First Cow Run.

The success of the Moore and Wittekind farms led to explorations in all directions. Along the east side of the latter tract an almost unbroken line of dry holes has been drilled, and the same is true of an east and west belt running through the Moore farm, so that the limits of the pool have already been determined. Westward, however, more favorable results have been secured. On the Cook farm adjoining the Moore, 15 wells have been drilled, 4 of which were failures. All are in the First Cow Run sand except one which has a depth of about 1300 feet and is reported to be in the Salt sand. The wells are now all small, the combined production being in August, 1900, about 25 barrels per day of 12 hours. Oil taken from the tank on this farm showed a gravity of 43½ degrees B. Lying south of the Cook farm is the Rupert on which there were 7 producers, and 2 dry holes. Four of these are in the First Cow Run and the others were reported in the Macksburg 800-foot sand, the latter being found at about 1,100 feet. The Rupert farm is joined on the west by the Dye. On this 15 wells have been drilled, of which one produced gas and two were failures. The gas and one oil well have been abandoned, so that there were 11 producers which made 25 barrels per day. With the exception of the gas well all are in the First Cow Run sand. The last productive farm along the river is the Cone; on this 4 wells have been

drilled, two of which were dry and one produced some gas. The oil well was producing about 1 barrel per day when the place was visited.

The narrow strip running northwest from the farms now discussed presents nothing that requires special mention. The wells are all reported in the First Cow Run sand, and the depths support that statement. As a rule the wells are small; the best producer was drilled on the Charles Purdue farm near Tunnel station in September, 1894, and began flowing 500 barrels per day, but in August, 1900, produced only 4 barrels in 24 hours. The initial production of most wells is insignificant compared with this one. As has already been stated this strip is very narrow, and when it reaches Turkey Hen creek is not more than 200 feet in cross section.

The little pool on the Potmyer and adjacent farms was opened in 1892. The first well made a show of oil and gas, but was never pumped and has long been abandoned. The First Cow Run sand was reported at 645 feet, and made a show of oil; another sand, probably the Dunkard, was found between 700 and 800 feet, and a third called the Macksburg-800 at 1,145 feet. The contract, however, required that the driller should reach the Berea, and work did not cease until a depth reported at 2,200 feet had been attained. The same year a well having a similar depth was drilled on the Bohl farm, 2 miles north, but without success. About the same time a well was drilled on the H. C. and C. S. Benedict farm along Turkey Hen creek. It is reported to have gone to the Berea, and to have made a show of gas. In 1893 a well was drilled along the same creek on the Porter farm. A small production was secured in the First Cow Run sand at a depth of about 650 feet. From here drilling progressed southeast toward Tunnel station. No further work was done on the Potmyer farm until 1898, when a well starting at 25 barrels was secured in the First Cow Run sand. A small number of producers have been found on this and adjacent farms, but the wells are all small, the combined production being less than 20 barrels per day in the summer of 1900.

Geology of the Field.—The surface formations lie quite largely in the Dunkard series or Upper Barren Coal Measures, the Washington coal according to Prof. I. C. White being found about 50 feet above the valley at Moore's junction.[1] Outside of the principal valley the topography is very rugged, and naturally the depths of the wells vary greatly. The surface formations consist chiefly of sandstones and shales, and hence do not contain strata of the most value in stratigraphical determinations. As has already been said a low arch crosses the river near the junction. Its direction northwest has not been traced, but oil and gas are not found along this line for more than one mile. The narrow strip which runs northwest past Turkey Hen creek also has an arch at its southern terminus,

[1] *Geol. Sur. of West Va.*, Vol. I, p. 288.

and this in all probability is found at all points along the territory. This arch is not conspicuous, and was detected by running levels from well to well.

No complete logs of wells were secured, and the following is taken from White's report to which reference has just been made. The well is No. 4, on Moore's farm, in the valley, a short distance from the Ohio river:

	Thickness of formation. Feet.	Total thickness. Feet.
Unrecorded	565	565
First Cow Run Sand	23	588
Unrecorded	157	745
Sand, some gas (Dunkard?)	100	845
Unrecorded	90	935
Second Cow Run Sand, strong gas	15	950
Unrecorded	92	1,042
Macksburg 800-Foot sand, some oil	61	1,103
Unrecorded	282	1,385
Big Injun Sand (water at 1,400 ft., filled up at 1,440 ft.), the bottom at	55	1,440

The thick sand struck at 745 feet, Professor White regards as the equivalent of the Cow Run or Dunkard sand of West Virginia. In other words the Cow Run sands of the two states are not stratigraphically equivalent—an important fact to remember. As has already been stated the First Cow Run sand in Ohio lies either on or a short distance above the Cambridge limestone in the Conemaugh formation or Lower Barren Coal Measures, while according to White, the Cow Run or Dunkard sand of West Virginia lies just above the Upper Freeport (No. 7) coal and hence makes the basal member of the Conemaugh formation.[1] This sand is known as the Mahoning, and in the Hocking Valley coal fields lies directly below or very close to the Cambridge limestone. Since in the well record just given the sand lies 157 feet below the First Cow Run it seems clear that it cannot be the equivalent of the Mahoning. In this state the latter formation is finely shown along the valley of Sunday Creek in Perry county, where it is quarried by the T. & O. C. R. R. Under cover, however, it loses its character, and is commonly replaced by shales in whole or in part, and so cannot ordinarily be recognized by the driller. The sand marked Second Cow Run is probably the Macksburg 500-foot, while that marked 800-foot appears to be the equivalent of the Second Cow Run.

The Oil Sand.—As has been stated there are three producing sands in this pool. The First Cow Run is normal, so that what has been said of it in other fields applies equally well here. Ten well records on the Moore farm show an average thickness of 23 feet, but in other places it is much

[1] *Geol. Sur. of West Va.*, Vol. I, p. 201–2.

thinner, and not unfrequently disappears, its place being occupied by shales. Along Turkey Hen creek the sand lies about 100 feet below the "Big red" (shales) which is 85 feet thick, and below which a thin stratum of limestone has been reported. This may be the Ames or Crinoidal limestone. The "Big Red" is reported to be very persistent, and so is of considerable importance in stratigraphical work. The data at hand do not warrant any discussion of the deeper sands locally known as the Salt sand, Big Injun, Keener, etc. They are of little importance in this territory.

WELLS IN THE EASTERN HALF OF WASHINGTON COUNTY.

Marietta Township.—The existence of oil and gas at Macksburg and Cow Run, and in other parts of the country stimulated the citizens of Marietta to search for these fuels, and particularly for gas which was promising so much for those cities favored with a supply. The drill has descended not only to the Berea, but has passed through nearly 1,200 feet of the underlying Ohio shales. The search, however, was unsuccessful, and left little room to hope for a supply near the city.

The first well of which the Survey has secured record, was completed January 24, 1886, and was located near the eastern limit of the city. For information concerning this, and the following log, the Survey is indebted to Mr. Joseph Garry. The well was called the Brick Yard well:

	Thickness. Feet.	Total depth. Feet.
Red mud	30	30
Gray sand	6	36
Red rock, 90 ft. of 7⅝ in. casing	54	90
White sand	35	125
Red rock	40	165
Light slate	45	210
Dark gray sand	8	218
Red rock and white slate	102	320
Dark gray sand	7	327
White slate	48	375
Good white sand	25	400
Red rock and blue slate	120	520
Bastard Sand—*First Cow Run*	10	530
Blue slate	40	570
Red rock	25	595
Blue slate, show of coal	40	635
Black and blue slate	95	730
Bastard sand—*Dunkard?*	10	740
Blue slate	18	758
White sand, 783 ft. of 5⅝ in. casing	25	783
White sand	67	850
Blue slate	75	925
Good white sand, show of oil (*Second Cow Run*)	20	
Blue Slate (*Second Cow Run*)	30	
Sand and salt-water (*Second Cow Run*)	25	1,000

	Thickness. Feet.	Total depth. Feet.
Blue slate	22	1,022
Coal	2	1,024
Light colored slate	76	1,100
Dark sand	5	1,105
Blue slate	35	1,140
Sand	10	1,150
Slate	10	1,160
Slate and shells	30	1,190
Sand	10	1,200
White slate	35	1,235
Slate and shells	23	1,258
Salt sand, little gas	145	1,403
Slate	6	1,409
Big Injun sand	145	1,554
Slate	231	1,785
Black slate	45	1,830
Berea sand (dry)	10	1,840
Slate and shells	163	2,003

However, in Pennsylvania large supplies of oil and gas are found in rocks below the Berea, and with hope of striking one of these another well was drilled which passed through nearly 1,300 feet of the underlying Ohio shales, but without finding an important sandstone stratum. The log of the Rake well below the Berea, which is taken from Dr. Orton's report, is as follows.[1] The well was begun March 18, 1886:

	Thickness of formation. Feet.	Total depth. Feet.
Bottom of Macksburg sand (Berea)		1685
Light slate and shells	28	1,713
Blue shale with slight changes in color, and hard sand	226	1,939
Soft brown sand	9	1,948
Slate and shells	94	2,042
Slate, no shells	16	2,058
Slate and shells	22	2,080
Brown sand	3	2,085
Sand and slate	5	2,090
Brown sand	5	2,095
Light slate	20	2,115
Slate and sand	5	2,120
Slate and sand	10	2,130
Slate	10	2,140
Slate and sand	28	2,168
Light slate	7	2,175
Slate	5	2,180
Slate and sand	8	2,188
Slate	7	2,195
Light slate	15	2,210

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 400.

	Thickness of formation. Feet.	Total depth. Feet.
Dark slate	27	2,237
Light slate	48	2,285
Dark slate	40	2,325
Light slate	80	2,405
Slate and sand	11	2,416
Slate	69	2,485
Slate and sand	10	2,495
Slate	15	2,510
Soft slate	55	2,565
Slate	55	2,620
Slate and shells	10	2,630
Slate	15	2,645
Black slate	95	2,740

In 1900 several wells were drilled for oil within or near the corporation limits. On the George Cisler tract of 20 acres, 8 wells were sunk, 3 of which were failures. The depths ranged from 430 to 495 feet. On the Jacob Gedell farm there were 3 producers and 2 dry holes, and a 6th well was being drilled when the territory was visited (July, 1900). Well No. 1 was completed in March, 1900, and started at 117 barrels. Its decrease was very rapid and on July 30th following, produced only 2 barrels per day. The sand in this well was 30 feet thick and the top lay 390 feet below the surface. Well No. 4, drilled early in June, 1900, flowed through the casing, producing 90 barrels daily, but like all the wells in this sand its decrease was very rapid, and by the close of the next month was yielding from 3 to 4 barrels only per day. These initial productions are very exceptional, the average being a small fraction of them. Wells have been drilled on adjacent tracts owned by Mash, Lawrence, Rathbone and Ellenwood, but the results have been discouraging. The position of this sand is reported immediately above the "Big Red," the latter lying about 90 feet above the First Cow Run sand. It is the equivalent of the sand found on the Mitchell farm about 2 miles east, and hence is generally known as the Mitchell sand. Oil taken from the Gedell tank showed a gravity of 43 degrees B. On the Headley farm lying one-half mile northeast of the tract just discussed, two small producers have been found at depths of 239 and 242 feet. This sand lies nearly 200 feet above the Mitchell, and is known as the Goose Run. A number of shallow wells have been drilled along Duck creek where it flows through the township, but no producers of importance have been found.

These wells were very short lived. Many were abandoned in the fall of 1900 and when the territory was re-visited two years later not a well was to be found.

The Goose Run Pool.—This was developed in 1899-1900, and lay in sections 11, 12, 17 and 18, immediately north of the Infirmary farm. Nearly 50 wells, of which one-half were dry, were drilled in this field.

The sand, which is known as the Goose Run, is found at a depth of 150 feet along the stream of the same name. It lies above the Mitchell sand as is shown in the following record of Reed well No. 4:

	Feet.
Goose Run sand, top	300
Goose Run sand, bottom	331
Mitchell sand, top	525
Mitchell sand, bottom	546

This makes the interval between the two 194 feet, though it is reported to drop as low as 169 feet.

The Goose Run sand may begin producing at a high rate, but invariably its decrease is rapid, and the life of the wells short. Thus one drilled on the William Covey farm in the spring of 1899 started at 100 barrels, but decreased very rapidly and in a year was abandoned. The remaining wells started much smaller, but their decline has been almost as rapid. In fact, when the field was re-visited in 1902, there was scarcely a well to be found.

The Mitchell Pool.—This lies immediately south of the Infirmary farm, and has a length of one mile, extending to the Little Muskingum river. It runs nearly due northwest and southeast. Nearly 50 wells, most of which were producers, had been drilled by August 1, 1900. The best well in the pool was struck on the Mitchell farm June 19, 1899, and started flowing 100 barrels per day, filling two 250 barrel tanks before it was tubed. One year later it was producing approximately 3 barrels per day. Other wells started smaller, but declined as rapidly, and no well in the pool can be relied on to produce more than 3 or 4 barrels per day a few weeks after it has been completed. The wells are all shot, the charges reaching 60 quarts. Oil taken from the tank on the Scott farm showed a gravity of 41 degrees B.

The sand is called the Mitchell. Its position with reference to the First Cow Run is shown by the following skeleton record of a well on the Cain farm:

	Feet.
Top of Mitchell sand at	415
Top of First Cow Run sand at	600
Top of Second Cow Run sand at	1,000

The Hendersho. Pool.—This lies west of the Little Muskingum in the angle made by it and the Ohio river. The principal farms are the Hendershot and Buel. The first successful well in this pool is reported to have been drilled on the Hendershot farm in 1896. In all 23 wells had been drilled on this farm, 9 of which were dry when it was visited in August, 1900. Of the producers 2 had been abandoned, and the remaining ones made approximately 33 barrels per day of 12 hours. The best

well on this farm started at 125 barrels. The sand, which is from 15 to 20 feet in thickness, is the First Cow Run, and lies about 650 feet below the surface. Near the river little salt-water is found, but farther back it causes considerable trouble.

On the old Buel farm 12 wells have been drilled, 2 of which were failures. The 7 oil wells are in the First Cow Run sand, but the gas well extends to a depth of 1,100 feet. Only 4 of these wells were producing in August, 1900.

The Sand Hill Pool.—This lies on the opposite side of the Little Muskingum river from the Mitchell and Hendershot pools. The central part of the territory is in sections 3 and 9, but a narrow strip runs south to within a half mile of the Ohio river, and another east into sections 33, 27 and 22 of Newport township. Thus, in a general way, the productive area is triangular in shape, and as will be shown later each side of the triangle lies in a different sand.

The first well in this pool was drilled in August, 1895, on the farm of John Riley in section 3. It started at 80 barrels, and at once drilling began in earnest. By August, 1900, about 75 wells had been drilled within a radius of one mile from the Riley farm. The wells in the strip running south from the center of the field are nearly all in the Mitchell sand, but occasionally one is found deeper. Thus on the West farm, one-half mile east from the mouth of the Little Muskingum, a gas well was struck at a depth approximating 1,100 feet. Ten weeks after drilling it is reported to have had a closed pressure of 450 pounds, and a flow of 1,000,000 cubic feet per day. The Mitchell sand is found on this farm at a depth ranging from 500 to 560 feet. The sand is fine, and is shot with from 40 to 80 quarts of nitroglycerine. The wells are small and have a settled production of about 2 barrels each per day.

On the Anna Alcock farm (now the Perkins) a well was drilled several years ago to a depth of 1,105 feet. In the top of the sand, struck at 1,042 feet, much gas was found. At 1,070 a break of 5 feet was struck, below which 30 feet of sand were found. After shooting the lower stratum with 100 quarts of nitroglycerine, a strong flow of oil, amounting to 100 barrels per day, was secured. This sand is regarded by the driller as the Second Cow Run, and its position appears to be about correct for that formation. On the Thorniley farm, lying just east of the Alcock, a 20 inch seam of coal was found 65 feet below the surface, and 466 feet deeper the Mitchell sand was struck.

The wells in the narrow strip running east from the centre of the field are nearly all in the First Cow Run sand. On the John Riley tract this sand is struck at depths ranging from 575 to 625 feet, depending on the surface altitude. This shows a rise eastward since on the lower land of the Hendershot farm, lying one and one-half miles west the sand is struck at about 645 feet. The rise between these two farms must be at

least 50 feet. Following the territory eastward into Newport township little change is noted. The productive area there is very narrow, not being more than one-eighth of a mile. The altitude is greater, and accordingly the wells deeper. Occasionally a producer is found in a sand other than the First Cow Run. Thus on the Close farm in the northwest corner of section 27, one well is in a shallower sand, and on the Conger farm in the same vicinity 2 additional shallow wells are found. The latter lie only about 90 feet above the Cow Run, and so cannot be classed with the Mitchell sand. The wells in this part of the Sand Hill pool are all small, and cannot be depended on for more than from 2 to 4 barrels per day, a few weeks after having been completed.

A number of wells have been sunk in the valley of the Ohio between the mouth of the Little Muskingum and the eastern boundary of Marietta township, but no important producers have been secured.

THE OIL POOLS IN NEWPORT TOWNSHIP.

This township lies east of Marietta and is bounded on the south by the Ohio river. It is an important producer of oil, having had over 300 wells in operation in 1900. There are 3 pools, and besides these a number of scattering wells along the Ohio river:

1. The Newell's Run Pool.
2. The Bosworth Pool.
3. The Sand Hill Pool. (See Marietta township.)

The Newell's Run Pool.—This is the most important one in the township, containing more than 175 producing wells. It is named from the West Fork of Newell's run which traverses the principal part of the territory. The productive area includes the whole or parts of sections 10, 11, 12, 18, 24 and 30 of Newport township, and 13 of Lawrence; the last section practically uniting the field with Cow Run, but for convenience the two are considered separately. The principal part of the field has a length of 4 miles, and extends west of north. It crosses Eight Mile run near Gracey P. O., along which a narrow strip extends west of south for a distance of 3 miles. The maximum width of the field is one mile, but throughout the larger part does not exceed one-half mile.

The first producing oil well in this pool was drilled on the land of John Berg along Eight Mile run in the spring of 1890. About one month after this well had been begun, the Boston Oil Company started a well at Gracey P. O. in the southwest corner of section 13, Lawrence township. It was decided to make this a test well, the objective point being the Berea. Progress was slow; the tools became fast several times; once the rig caught fire and was destroyed; other difficulties incidental to deep wells, prolonged the work, so that the well was not completed until the following November. The First Cow Run sand was reported at 585 feet, and from it there was a flow of oil. The Berea was struck at a depth

of 1,932 feet, and though only five feet thick contained much gas, the closed pressure being reported at 440 pounds. The fuel was used in developing the surrounding territory, and the well is still producing. The discovery of large supplies of gas made operating much easier, and drilling progressed rapidly. The limits of the field appear to be now pretty definitely determined, though doubtless a fair number of producers will yet be secured. In 1901 the Berea sand was tested, 3 wells having been sunk on the Stephens farm. The best well produced 20 barrels of oil the first day and one the next. All were soon abandoned. From well No. 28 on this farm the following data were taken:

	Feet.
First Cow Run sand at	505
Salt sand at	1,210
Berea at	1,848

Geology of the Field.—This is of interest since it lies on the Burning Springs anticlinal which crosses the Ohio near the mouth of Newell's Run, and is known on this side of the river as the Newell's run uplift. The arch must be given high rank among structures of this kind in Ohio. Its magnitude is shown by the fact that at Eureka, West Virginia, the Berea is found at a depth of 1,350 feet, while 4 miles southwest on the Palmer farm, a well drilled on the river bank at practically the same surface altitude found the sand 1,950 feet below the surface, showing a fall of 600 feet in that distance. Passing eastward the same conditions hold, only the crest of the arch having been crossed the strata dip to the east. Thus a little more than one mile east from the mouth of Newell's run, the wells on the Ohio side of the river strike the Berea at approximately 1,600 feet; while at St. Mary's, West Virginia, 3 miles east from Newell's run, the formation lies 1,900 feet below the surface.

The arch has long been known. It appears to have been described for the first time by Prof. E. B. Andrews in the American Journal of Science for July, 1861,[1] and subsequent reference is made to it by the same writer in his report on the Geology of Washington county published in 1874.[2] According to this geologist the arch crosses the river near the mouth of Conley run, which unites with the Ohio nearly 2 miles above Eureka. Hence, the Berea should be found there at a smaller depth than at Eureka. The First Cow Run sand is placed 200 feet below the surface in the Eureka well by Professor White, while according to Andrews it is actually above drainage at the mouth of Conley run. According to this the Berea should be found at a depth of not more than 1,150 feet at the latter place. The dip, then, between this point and St. Marys, 3 miles

[1] *Am. Jour. Sci. and Arts*, Vol. XXXII, new series, pp. 85–93.
[2] *Geol. Sur. of Ohio*, Vol. II, pp. 501–505.

distant, is 850 feet, making the eastern slope of the arch much steeper than the western one, as Andrews claims. It should be noted, however, that the dip on the western slope has not been measured at right angles to the direction of the uplift, which is nearly north and south, but at a smaller angle than 90 degrees, and consequently the dip stated is less than the real one on this slope. On the east side the measurement has been made on a line approximately at right angles to the line of uplift.

After entering Ohio the arch flattens and is soon lost, while in West Virginia, according to Andrews, it becomes more prominent, attaining a maximum near Petroleum, Wirt county.

In his report on Washington county, already referred to, Andrews gives a section at the mouth of Conley run, the top of which he considers the Cambridge limestone. Forty feet lower is a coarse sandstone which he calls the First Cow Run. The section is as follows:

	Feet.	Inches.
Fossiliferous limestone (Cambridge)	1	6
Yellow shales	18	0
Slaty coal	0	8
Clay and coal	0	6
Fire clay, light colored	0	6
Coal	0	6
Not exposed	20	0
Sandrock, First Cow Run	25	0
Iron ore, adhering to sandrock	0	6
Blue clay shale, with modules of iron ore	1	6
Level of water Ohio river.		

The limestone, however, is the Ames and not the Cambridge, and hence the sand below cannot be the First Cow Run. The limestone has all the characters of the same formation farther west and there can be no reasonable doubt as to the correctness of its identification. Its presence above drainage appears all the more remarkable when it is considered that westward it is not found above cover nearer than the valley of Federal creek in the western part of Morgan county. The distance between these two exposures is about 40 miles. Since this limestone is found above drainage along Conley run, it follows that both the Meigs Creek and Pomeroy coals are due in the adjacent hills. The seams are found at their proper positions, but both are small and unimportant.

It is of interest to note that the Newell's run pool lies on the western slope of the axis, and as will be shown later, the Bosworth pool on the eastern slope, the crest of the axis being unproductive, if the holes thus far drilled can be relied on.

The wells are all small. Even when they start at from 10 to 25 barrels or more per day, they soon decrease so that their output is a small fraction only of their initial production. However, after their settled pro-

duction is reached they continue without important change for years. The data already given illustrating the life of wells in the Joy, Buck Run and Cow Run fields show the staying quality of the sand, and there is no reason why the records in those pools should not be duplicated here. Below the production of a few farms is given (August, 1900). They have been selected at random and represent very well the average for the field:

Noland, section 11, 11 producers, 30 barrels per day.
Reese, section 11, 21 producers, 50 barrels per day.
Gracey, section 13, 15 producers, 20 barrels per day.
Hall, section 12, 22 producers, 25 barrels per day.

From these farms it appears that the average production of the wells is less than 2 barrels per day. The daily output of the entire pool was about 300 barrels at the date above mentioned.

The Productive Sands.—There are 4 of these: (1) The First Cow Run, (2) The Priest, (3) The Salt sand, and (4) The Berea. Besides these a well or two is reported in the Second Cow Run, but as will be shown later this cannot be the true sand bearing that name.

The First Cow Run sand is the only large producer in the field. It is found at a depth of 300 feet along the run on the Noland farm in section 11, and at 478 feet in the bed of Eight Mile Run in the northwest quarter of section 18. The sand appears in all respects normal.

The Second Cow Run sand is placed by the driller about 180 feet below the first sand, and this in those parts of the field nearest Cow Run, where it will be remembered the interval between the sands is 400 feet. It scarcely needs be stated that the sand in question cannot be the true Second Cow Run. Its position corresponds more closely with that of the Dunkard sand of the West Virginia survey.

The Priest sand supplies a few wells on Eight Mile Run in sections 24 and 30. It is reported to lie 150 below the Second Cow Run, so called. Its position with reference to the First sand, however, strongly suggests that it is nothing more than the Second Cow Run sand.

The wells in the Salt sand are as follows: 2 (both dry) on the Becker farm in section 30 along Eight Mile Run; 3 producers and 5 dry holes on the William Mendenhall farm in sections 24 of Newport, and 19 of Lawrence townships, the sand being struck along Eight Mile Run at a depth of almost 1,100 feet; 3 wells on the Berg farm in section 24, at a depth of 1,110 feet in the bed of the run. The wells in this sand have been of little commercial value. Those on the Berg farm are reported to have had a settled production each of 10 barrels per day. But one of them has been abandoned, and the remaining 2 produce conjointly 2 barrels only per day. The sand is reported to be quite free from water.

The Berea wells are as follows: One at a depth of more than 1,800 feet on the Reese farm in the northwest quarter of section 11, making a showing of oil; a strong gas well (already reported) at a depth of 1,932 feet at Gracey P. O.; two on the Becker farm in section 30, the sand having been found at a depth of 1,725 feet in the bed of Eight Mile Run; a dry hole on the Mendenhall farm in section 24; a gas well on the Berg farm in the northwest quarter of section 18. It is plain that the Berea is not an oil sand in this field. It produces, however, some gas—a great boon to the operator in a district without coal.

THE WELLS IN INDEPENDENCE TOWNSHIP.

This township lies north of Newport, and contains two pools: (1) Archer's Fork; (2) Elk Run. The two are closely related in every respect, but are considered separately in this report as a matter of convenience. Topographically considered the township is very rugged. The valleys are narrow, and the hillsides unfertile, so that the oil has proved of more than ordinary help to the residents.

Archer's Fork Pool.—This lies in sections 32, 33 and 27, and includes a small part of section 2 of Lawrence township. The length of the field is 2 miles, and the width does not appear to exceed one-half mile. The oil sand runs 40 degrees east of north. The pool is said to have been discovered 10 or 11 years ago when wells were drilled on the Davis and Ward farms. From that date drilling has been quite active until 1900. The wells are nearly all in the Berea, which appears normal, and is found on Archer's Fork at a depth of 1,780 feet. Occasionally a little oil is found in the First Cow Run and the Big Injun sands, the latter lying 380 feet above the Berea. Considerable gas is sometimes found in a sand called the Second Cow Run. The wells at first contain sufficient gas to flow the oil, but the older ones have to be pumped. The number of producing wells in this pool in August, 1900, was less than 50.

The Elk Pool Run.—This lies north of the last named pool, and includes a part of sections 29, 35, 30 and 24. As developed in 1900 its length was 2 miles, and its width three-fourths of a mile. The first producing well in the pool was drilled on the Mary Smith farm in the spring of 1898, and work was active until the close of 1900. Comparatively few dry holes have been drilled thus far, but the great depth of the wells and the small settled production have had a discouraging effect, so that very little work has been done since 1900.

The producing sand is the Berea, and is reached at depths ranging from 2,000 to 2,200 or more feet. However, a showing of oil is made in the Big Injun, Keener, Maxton and other sands. The succession of these sands is shown by the following skeleton section of a well on the Mead farm, furnished the Survey by W. T. Hastings:

Coal	top at 400 feet bottom at 402½ feet
Salt sand	top at 1,200 feet bottom at 1,280 feet
Maxton	top at 1,450 feet bottom at 1,500 feet
Mountain limestone	top at 1,510 feet bottom at 1,545 feet
Keener sand	top at 1,560 feet bottom at 1,615 feet
Big Injun and Squaw sand	top at 1,615 feet bottom at 1,730 feet
Berea sand	top at 2,124 feet bottom at 2,138 feet.

Other records provided the Survey by the same operator duplicate the one given, so that this may be regarded normal for the territory. The section contains several formations new to this report, and these will be reviewed here in order that what follows may be more clearly understood.

The great "key rock" by which the driller determines his position stratigraphically in this part of the field is the Mountain limestone, or the "Big lime" as it is commonly called. Its thickness in this pool commonly ranges from 35 to 50 feet. Westward it thins and does not appear at all in the Marietta and Macksburg sections. The farthest point west at which the writer found it reported is at Fifteen P. O. in section 7 of Liberty township, where it ranges in thickness from 0 to 20 feet. East from this place it is always present, making a datum plane of unusual value to the driller.

Resting either directly on this or separated from it by a few feet of shales is frequently found a sand rock which produces some oil, and is called the Maxton.

Immediately below the "Big lime" is a series of sandstones and shales known collectively as the Big Injun in which large quantities of oil are found in several pools. Occasionally, however, the formation consists of an unbroken sandrock from top to bottom. The upper part of the formation when separated from the lower by a few feet of shales is known as the Keener sand, named from the Keener farm near Sistersville, West Virginia. The succession there according to Professor White is as follows:

Big Lime (Mountain).

Big Injun	*Keener sand*	30 ft.	125 feet.
	"Break" (slate)	15 "	
	Sand	80 "	

In some cases an oil sand is found below the body of the Big Injun from which it is separated by a few feet of shales. This sand is called the "Squaw," a term used by the driller in about the same sense as the "stray."

West of Independence township the Big Injun is not a producer of oil or gas. In fact in the central part of the county it is not well marked, being there confused with the Salt sand. Eastward, however, where the "Big lime" is found its separation from the Salt sand is easy, and its identification certain.

The Berea in the Elk Run field ranges in thickness from 0 to 20 feet or more. The sand varies considerably. Sometimes it is coarse, porous and soft, and at other times fine and hard. Above and below it is succeeded by a dark shale. The sand contains but little water.

The largest producer in the field is reported to have started at 800 barrels. It was drilled early in 1899, and in August, 1900, was producing 40 barrels daily. Ordinarily the initial production of the wells was about 40 barrels per day. At first the wells flowed, but the gas pressure soon dropped so low that they had to be pumped. The oil has a density of 51 degrees B. The number of producing wells in the field in August, 1900, was about 65. The wells are shot with heavy charges of nitroglycerine, usually from 80 to 90 quarts. The sand, however, clogs rapidly, and then the wells are shot a second time. This process may be repeated later.

Other Wells in the Township.—The number of wells drilled outside of the two pools is not large, and nearly all have been failures. The record is as follows: A dry hole on the Ward farm along the western line of section 35; a dry hole on the Miller farm along the south line of section 18; 3 dry holes on the Hanlon farm, which joins the Miller; one dry hole on the Patterson farm along the south line of section 23, but a half mile farther south on the Hall land near the middle of section 22 a fine gas well has been secured; a dry hole on the Cady farm in the northeast quarter of the same section; one dry hole on the McKnight farm in section 10, and one on the Deucher farm in section 21.

On Leith run in the southeastern corner of the township, 9 wells have been drilled, only 3 of which were producers. A good gas well was struck at a depth of 1,100 feet on the Kiger farm. The remaining wells are in a shallow sand, struck at about 300 feet. On the Farnsworth tract in section 9 a small producer, now abandoned, was secured in a shallow sand, and a second well is being drilled (1900). On the Valentine farm in section 24 one dry hole has been drilled, and one mile southwest on the Bosworth farm in section 23 a gas well, now abandoned.

WELLS IN LUDLOW TOWNSHIP.

This township lies north of Independence, and extends to the Monroe county line. The Little Muskingum river flows zigzag fashion through

the township from the northeast to the southwest corners. The valley is very deep and hence strata are exposed that otherwise would not be seen. On Wingett's run in the northwest corner of the township Andrews has reported both the Meigs Creek and Pomeroy coal seams, the interval between the two being 94 feet. Both have been mined in that locality, but they are small and consequently unimportant. At Flint's Mills, in the southeast corner of section 21, the Pomeroy coal was formerly mined for local consumption. The seam is on a level with the river valley, and is covered with several strata of limestone. There are three pools of oil and one reservoir of gas in this township. All lie in the same vicinity, and might be considered as one. These are:

1. Hohman (oil).
2. Wilson Run (oil).
3. Flint's Mills (oil).
4. Wingett P. O. (gas).

Hohman Pool.—As developed in 1900, this consisted of an area of approximately one square mile, including parts of sections 7, 8, 13, 14. The first well is reported to have been drilled in 1896 on the Delong farm, in section 7. It yielded a heavy flow of gas, and is now in control of the Carter Oil Company, which uses it as fuel in drilling and pumping. Work has been actively in progress from that time until the close of 1900. The number of producing wells in August of that year was 20. The oil is derived chiefly from the "Squaw" sand, the Berea being a small producer. The following generalized section of the sands is interesting:

		Feet.
Maxton sand		10-15
"Big lime"		40-90
Big Injun sand	Keener sand 10-15	118-170
	Big Injun proper..100-120	
	Squaw sand 8-35	

The "Squaw" sand is separated from the heavy ledge of sand above by from 2-15 feet of slate. The wells usually begin at from 25 to 50 barrels daily, and maintain the initial ratio fairly steady. Thus a well drilled on the Cross farm in April, 1900, starting at 30 barrels, was producing 20 barrels daily the following August. The wells are shot with from 40 to 120 quarts of nitro-glycerine, the size of the shot depending on the hardness and thickness of the sand. The oil from the "Squaw" sand has a gravity of 44½ deg. B. The Berea is finer and harder than the "Squaw." Its thickness ranges from 7 to 12 feet, but in one well the sand was absent, its place being occupied by shales.

The Wilson Run Pool.—This lies north of the Hohman and includes parts of sections 3, 4, 9 and 10. Northward it extends into Monroe

county, where it is known as the Rhinard's Mills pool. The principal part of the territory extends nearly north and south, and has a width ranging from one-quarter to one mile or more. Throughout much of the area the Little Muskingum river flows, its deep valley diminishing by two or three hundred feet the distance to be drilled. The pool is reported to have been first struck on the Beaver farm 7 or 8 years ago, though active work did not begin until 1897, when a 500-barrel well was secured on the Edwards tract in the southwest corner of section 4. The greater number of the wells, however, were drilled in 1899. The number of producers in August, 1900, was nearly 80.

The oil is found in the Big Injun and Berea sands. With two or three exceptions the wells on the east side of the river are in the former, while more than half of those on the west side are in the Berea. The Big Injun sand is reported to be from 65 to 70 feet ordinarily in thickness. The oil is found in the upper half of the rock, the pay streak ranging from 6 to 8 feet in thickness. Along the river in section 4 the Big Injun is found at a depth of 1,375 feet, and the Berea at 1,880. The drillers claim to recognize the Keener sand, and report it separated from the "Big lime" above by a few feet of shale, and from the sandstone below by from 1 to 6 feet of the same material. Its thickness is given at 40 feet. The Berea commonly ranges from 5 to 10 feet in thickness, but sometimes disappears, its place being occupied by shales or shaley sandstone. When the wells are shot the first time the charge is small, usually about 20 quarts, but as the wells are shot a second or third time the charge is larger. At first the oil flows, but the gas pressure soon falls so low that the wells require pumping.

The Flint's Mills Pool.—This lies along the Little Muskingum river in sections 15, 16, 22, 21, 20 and 26. At first the work was largely confined to the valleys, but more recently it has extended over the hills. The length of the pool as developed in 1902 was 3 miles, and the greatest width one and one-quarter miles. As has already been stated, the Pittsburg or Pomeroy coal is exposed in the valley at Flint's Mills.

The first well in the pool is reported to have been drilled on the McLain farm in June, 1898. It extends to the Berea, and began producing 7 barrels daily, but two years later its production had decreased to one and one-half barrels. From that time work has been in progress; more than 100 wells having been drilled, of which approximately 90 per cent. were producers. The largest one thus far secured is on the C. & S. Graham farm, in section 20. It is reported to have started at 480 barrels, and to have produced 250 barrels per day for some time. Several months after completion it was still producing 150 barrels per day. This is one of the best wells yet drilled in southeastern Ohio. A well on the Elizabeth Smith farm, in section 21, drilled in December, 1899, and shot with 40 quarts of nitro-glycerine, started at from 8 to 10 barrels, and maintained

this rate for 2 or 3 months. It was then shot with 40 quarts and its production increased to 110 barrels. Later it was again shot, this time with 80 quarts, and the production increased. On August 14, 1900, it was shot with 40 quarts, the production starting at from 50 to 60 barrels per day. Nearly all the wells in the pool are in the Big Injun, an occasional one only reaching the Berea. The succession of sands is shown by the following skeleton sections:

Well No. 7, Watson Brothers' farm, located on bank of river, the top being at the horizon of the Pomeroy coal:

	Feet.
Cow Run sand at	500
Salt sand at	600
Maxton sand at	1,000
Big Injun sand at	1,400

Lucas farm, Well No. 1, data furnished by R. W. McConnell:

	Feet.
Cow Run sand at	580
Salt sand at	680
Maxton sand at	945
Big Lime at	1,181
Big Injun sand at	1,331
Berea at	1,823

The sand reported to be the Cow Run cannot be that sand, however. The interval between the First Cow Run sand and the Pomeroy coal at Macksburg is approximately 240 feet, while here it is reported to be 500 feet. The position of this sand with reference to the coal corresponds closely with that of the Dunkard sand in the Macksburg field.

There are 2 pay streaks in the Big Injun; one at the top, which usually produces some gas; the second lies 40 feet deeper and yields oil. The latter is from 4 to 6 feet thick, and is loose and pebbly. Occasionally, however, it is fine and hard, and then is dry. At first the larger wells flow, but the gas pressure soon falls so low that they require pumping.

The Wingett P. O. Gas Wells.—In the western half of sections 31 and 32 of Ludlow township, and the eastern half of sections 1 and 2 of Liberty township is a small but valuable reservoir of gas. The wells are all in the Berea sand. The first one drilled was in 1895 on the McCurdy farm, in the southwest corner of section 32. Its initial closed pressure was 850 pounds, but 2 years later, according to reliable persons, was 950 pounds per square inch. The well is located on the bank of the Little Muskingum, and reached the Berea at a depth of 1,687 feet. The well is the property of the Keystone Oil Company, and is used to supply fuel for drilling and pumping. The 6 remaining wells in the field belong

to the Carter Oil Company, and are used for a purpose similar to the well just mentioned. These had an initial rock pressure of from 750 to 900 pounds per square inch.

OIL WELLS IN GRAND VIEW TOWNSHIP.

This territory lies east of Ludlow and Independence townships. It is bounded on the north by Monroe county and on the south by the Ohio river. The topography is very rugged. Thus far the only oil found has been at two points along the river, one in the extreme southwestern corner, and the other in the northeast corner; the latter, however, forms part of the Sistersville pool, and so will not be considered in this place.

The Sheets Run Pool.—This lies in sections 22, 27 and 33. About 25 wells have been drilled in it, only 3 of which were dry. The best territory is on the Alonzo T. Dye farm. A well on this tract, drilled in 1896, started at 600 barrels per day, and produced 16,000 barrels the first year. By the close of that period the yield having decreased to 2 barrels, the well was shot with 6 quarts of nitro-glycerine, the production increasing to 125 barrels daily. On October 3, 1898, it was shot a second time, the charge being 10 quarts, with satisfactory results. The well was shot again March 31, 1899, with 40 quarts, and the production increased. On December 7, 1899, it was shot with 100 quarts, but the result was not beneficial. In the summer of 1900 the well was not pumped, but the proprietor expected to put it in condition again with the expectation of further production. It is claimed that the total yield of the well has been approximately 25,000 barrels. The sand from which the oil was procured is not definitely known, but it is said to be either the base of the Keener or the top of the Big Injun.

Nineteen feet above the place at which the oil was secured a heavy flow of gas was found, which blew the sand from the hole, and made further work difficult.

The wells on the north side of the place are in the Big Injun, and the 2 on the south side near the river are reported in the Maxton. The remaining wells, with one exception, are in either the Salt sand, Maxton or Big Injun. The well excepted is in a shallow sand. A well on the Riggs farm found the Berea at a depth of approximately 1,700 feet, but it gave no sign of oil.

Other Wells in the Township.—A number of wells have been drilled along the Ohio river between Sheets run and Matamoras. On the Beaver farm in section 28 a good gas well was secured in the Salt sand. The rock pressure is reported to have risen to 300 pounds in one minute after the guage was applied, and to have stood finally at 350 pounds. On the McMahan farm, east of the Beaver, 2 dry holes have been drilled, and another well was being put down when the territory was visited (1900). On the Cochran farm, in section 23, seven wells have been drilled. Of

these, 3 were dry, and of the producers one has been abandoned. They are in the Big Injun sand, and all are small. The Mountain limestone is reported having a thickness of from 80 to 120 feet.

Other failures in the township are as follows: One on the Collins farm, in section 24, and one on an adjoining farm, in section 18; one on the Williamson farm, on the south side of section 19; one on the Kraft farm, in section 8; one on the Grimes farm, along the west line of section 14; one on the Porter farm, in the northeast quarter of section 32; one on the Early farm, on the east line of section 15. A gas well is reported on the Algoe farm, in the southeast quarter of section 28.

OIL WELLS IN LIBERTY TOWNSHIP.

The Germantown Pool.—Several years ago a gas well was drilled on the Miller farm, near the village of Germantown. Encouraged by the result, another well was drilled on the farm in 1901, and a small oil well was secured. Other wells were drilled, and by 1902 quite a pool had been opened. The best producer started at 80 barrels and at the end of the first month was producing 40. The top of the sand lies 790 feet below the Pittsburg coal, and hence appears to be the equivalent of the Second Cow Run.

Considerable drilling has been done in the vicinity of Fifteen P. O. and a small pool secured.

The oil is derived chiefly from the Maxton sand, which lies immediately above the "Big lime." The latter has a thickness in this territory ranging from 0 to 20 feet, and has not been found by the writer farther west. Eastward, however, it is reported in every well that is sufficiently deep. Occasionally a small production is secured in a shallow sand, reported to be the First Cow Run. The best producers drilled in 1895, started at from 25 to 40 barrels, but are now very small.

Near the village of Dalzell, in section 22, two dry holes have been drilled. One is reported to have reached a depth of more than 1,100 feet, and the other 1,840 feet. Quite recently a small well was secured in the Big Injun in the northern part of section 1, near the Wingett P. O. gas wells.

WELLS IN SALEM TOWNSHIP.

This lies south of Aurelius township, and the wells in the northern part form a portion of the Macksburg field. The territory is traversed from north to south by Duck creek. There are no important pools in the township, but considerable drilling has been done.

Along Pawpaw creek, near Bonn P. O., more than 30 wells have been sunk, some of them many years ago. The recent work was begun about 1896. Only 5 of the wells were producing in August, 1900, and these made conjointly from 5 to 7 barrels per day. The sand is shallow, lying approximately 450 feet below the Meigs Creek coal.

The most terrible accident ever known in the oil territory of southeastern Ohio occurred in this field. In the spring of 1900 a well had been drilled on the Kelley farm and a charge of nitro-glycerine lowered to the bottom. The "go-devil" failed to discharge the shot; and then a "squib" containing about one-quarter of a pint of the same explosive, to which was attached a three-minute fuse, was dropped in the hole. This was followed by the discharge of the glycerine in the bottom of the well, and the spectators, thinking the action regular, ran to the derrick as soon as the eruption ceased. They had scarcely reached that place when there was another explosion, and 7 men were killed outright or so severely wounded that they afterwards died. Three others were wounded but recovered. It is not known definitely how the accident occurred. It seems probable, however, that the "go-devil" lodged in the well, and so did not reach the nitro-glycerine until after the "squib" was dropped. This released the "go-devil," which fell to the bottom and discharged the shot. The explosion blew the "squib" to the top of the well, but did not explode it. The fuse, however, continued burning, and at the end of 3 minutes discharged the "squib," with the terrible results mentioned.

About 2 miles north from Whipple 10 wells have been drilled on the Lauer, Babson and Blake farms. Of these 4 only were producers, and all were in a shallow sand. One mile northeast from Whipple 5 wells have been drilled on the Biehl farms, but little has been secured to repay the operator for his outlay. From this territory south to Marietta wells have been drilled from time to time in the valley of Duck creek, but they have been either dry, or so small that they can be recorded with the failures.

MONROE COUNTY.

This county, which lies north of Washington, is one of the largest producers of oil in the southern part of the state. It is also one of the most recent in development. The surface formations, consisting very largely of sandstones and shales, belong almost entirely to the Monongahela formation or Upper Productive Coal Measures, and to the Dunkard formation or Upper Barren Measures. The topography is very rough, especially in the southeastern part, where the hill-tops rise more than 600 above the valley of the adjacent Ohio. The oil is found principally in the southern half of the county, where, because of the infertility of the soil and ruggedness of the topography, it has proved a great boon to the residents. In this connection it must be borne in mind that the operator and owner of the land do not by any means derive all the benefits resulting from the discovery of oil. Those who own land adjacent to the producing territory option their property at a rate per month varying commonly from 10 cents to one dollar per acre. In many cases these options are carried for years, making in the aggregate a handsome sum for the farmer, without expense or trouble on his part. Besides, drilling and operating

furnish work for a large number of men and teams, and the wages are always excellent. The liveryman, grocer, butcher, gardener and, in fact, practically every man in the community is financially benefited.

The principal pools in the county are:

1. Sistersville.
2. Jackson Ridge (Griffith P. O.).
3. Graysville.
4. Moose Ridge.

Besides these the following minor pools are to be noted:

1. Clear Fork.
2. Clift.
3. Whitacre.
4. Rinards Mills.
5. Benwood.
6. New Castle.
7. Louisville.
8. Sycamore.
9. Jerusalem.

THE SISTERSVILLE POOL.

Location and Area.—This lies in the two states, Ohio and West Virginia, and is divided in two parts by the Ohio river, but that part only lying north of the river will be considered in this report. It comprises the southwestern half of Jackson township; sections 1, 2, 5, 6, 7, 8, 11 and 12 of Benton; sections 3, 9, 15, 16, 33 and 34 of Perry; and besides a strip about one mile in width along the eastern margin of Grand View township, Washington county, which joins Jackson township, Monroe county.

Discovery and Development.—In 1890 a "wild-cat" well was drilled a few miles back from Sistersville at a locality known as "Pole-Cat." A vast reservoir of salt-water was found in the Big Injun sand, and the well, which was considered valueless, was left standing idle for about 18 months. In April, 1891, a well was begun on the Ohio side of the river on the Stewart farm, opposite Sistersville, by Hatfield and Younger, of Pittsburg, for the Miller's Run Oil Company. The sand was reached May 14, and the well finally completed June 26. This was the first producer in the field, and marked the opening of one of the largest pools yet discovered in this country. When put to pumping it produced ordinarily from 10 to 15 barrels of oil per day, but with this a large amount of salt-water; sometimes when the latter was temporarily overcome the oil increased to 60 or 70 barrels per day. The productive sand is said to have been both the Keener and Big Injun, but principally the latter. Later in 1891 a well was drilled on the Russel Heirs' farm, adjoining the Stewart, and duplicated the record of the well just described. Other wells were drilled the following fall and winter on neighboring farms; oil was secured in all, but with it came a flood of brine.

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In the winter of 1891-2 a well was drilled in Sistersville, which produced oil and brine in large quantities, the former from 90 to 100 barrels per day. From this well drilling extended towards the "Pole-Cat" well, and large producers were secured, but in all cases a vast amount of salt-water with the oil. Finally in 1892 it was decided to begin pumping the "Pole-Cat" well, with the hope that by reducing the salt-water, oil might be secured. The quantity of brine pumped from this well is said to have been 3,500 barrels per day for weeks. At last it began showing oil and gas; this increased steadily until a production of from 500 to 600 barrels per day was secured. This triumph of the "Pole-Cat" well gave the field a great boom, and made it for the time the Mecca of the oil men of the country. Drilling progressed as rapidly as the energy of the driller and operator combined could push the work; many large wells were secured, the greatest on the Ohio side making 1,200 to 1,500 barrels daily. After the limits of that part of the field along the river had been determined, the drill moved northward, and a number of producers were secured along Trail run, in the northeastern corner of Benton township. That part of the field, however, is narrow and unimportant, but along the line separating Benton and Perry townships it expands, forming a fine pool. This is commonly known as the "Trail Run" or "Iron Bridge" field, and was opened in 1895, the first well having been drilled on the Mathias Dye farm. Late in the spring of that year a well producing over 300 barrels per day was completed on the Freedman farm, and early in August a large gusher was struck on the J. R. Diest farm. Oil was thrown over the top of the derrick, and it is estimated that 1,000 barrels were wasted before the well could be brought under control. This started the boom, and during the following year work was pushed with great vigor. On the Diest farm of 125 acres five or six strings of tools were at work at the same time. A number of fine wells were secured, the largest being J. R. Diest No. 4, which was estimated by the Buckeye Pipe Line Company to have produced 2,400 barrels the first 24 hours. It averaged from 700 to 800 barrels per day for a month. The oil sand is the Big Injun; rarely only is a well found in the Keener. The most striking feature of this part of the field in comparison with that along the Ohio river is the great decrease in the quantity of salt-water; so great is the change that the brine, instead of being a great obstacle, is really none at all.

From the area near the "Iron Bridge" the productive territory extends northwest to Mechanicsburg (Aitch P. O.), in section 16 of Perry township. This is the part of the Sistersville field that was last developed. A well was drilled on the Daniels farm about 1896-7, but owing to legal complications it was not pumped until 1899. Active work began that year, and was at its height in 1900. The producing sand is the Keener. All in all, the wells are smaller than those in other parts of the field; the largest started at 100 barrels, and the greater number at from 10 to 40

barrels per day. Like the territory around "Iron Bridge," salt-water is not an obstacle.

Geology of the Field.—The surface formations lie in the Monongahela formation or Upper Productive Coal Measures, and the Dunkard formation or Upper Barren Measures. The underground succession is shown by the following records:

G. Carpenter well No. 1, opposite Sistersville. Authority, Henry Oil Company:

	Feet.
Top of Cow Run sand	690
Bottom of Cow Run sand	705
Top of Salt sand	905
Gas at	910
Bottom of Salt sand	1,155
Top of the "Big Lime"	1,265
Bottom of "Big Lime"	1,300
Top of the Big Injun sand	1,300
Bottom of the Big Injun sand	1,430
Top of the Berea grit	1,804
Bottom of the Berea grit	1,807
Bottom of well	1,895

Well No. 14, J. R. Diest farm, on or near section 9 of Perry township. Authority, the Associated Producers' Oil Company. Data furnished to Survey by Mr. H. M. Stanberry, C. E. Surface elevation, 909 feet:

	Feet.
Conductor	10
Sandstone	80
Shale	20
Red rock	20
Shale	20
Sandstone	30
Coal (unmeasured)	
Shale	30
Sandstone with lime	30
Shale and shells	160
199 *ft. of* 10 *inch casing.*	
Sandstone	35
Coal in the sandstone at	420
Shale and shells	65
Limestone	35
Red rock	75
Slate and lime	25
Red rock	40
Slate and shells	90
Sandstone and lime	80
830 *ft. of* 8 *inch casing.*	
Slate and shells	100
Sandstone	25

	Feet.
Slate and shells	45
Limestone	10
Sandstone and lime shells	90
Black shale with coal seam	25
Sandstone	40
Dark shale	20
Slate	75
Dark sandstone	45
Light slate	100
Sandstone	20
Dark slate	50
1,490 *feet of 6¼ inch casing.*	
"Big Lime"	60
Keener sand, show of oil	25
Slate	15
Big Injun sand	18

The great guide-post of the driller in this part of the territory is the Mountain limestone or "Big lime," as it is popularly known among the drillers. This is everywhere present in the field, and has a thickness ranging from 35 to 110 feet. It has a light color, is quite hard and hence easily recognized. The great formation appears to be here unbroken, but farther north in this county it is interbedded with layers of sands which sometimes contain valuable deposits of oil. Directly above the "Big lime" a bed of sandstone is occasionally found; this sometimes makes a show of oil, but never becomes an important producer on the Ohio side of the Sistersville field. The West Virginia geologists call this sand the Maxton.

The Oil Sands.—The oil sands of this pool lie immediately below the Mountain limestone or "Big lime," and comprise the Big Injun group. This is here divided as follows:

The Big Injun group { Keener sand. / Shale (break). / Big Injun (proper).

The Keener sand, which lies immediately below the Mountain limestone, was named from the Keener farm, near Sistersville. On the Ohio side the sand has a thickness ordinarily of from 20 to 30 feet. It is frequently a producer of oil, but is not the principal source until the village of Mechanicsburg is reached, in the extreme northwest corner of the field. Below the Keener is a "break" or a bed of shale, having a thickness ordinarily ranging from 5 to 35 feet, and rarely disappearing altogether. Below the "break" lies the third member of the group, the Big Injun proper, having frequently a thickness of more than 100 feet. When the "break" disappears, the two oil rocks run together, forming a sandstone of great

thickness, which, of course, is known as the Big Injun. The thickness of the three formations ranges from 160 feet on the west side of the field to 250 feet on the east side.

The sand varies much in texture; sometimes it is fine and hard, at other times coarse and open. The latter is commonly true in the pay streaks, when the rock occasionally becomes a true conglomerate. In that part of the formation lying below the "break" two pays are occasionally found, the principal one lying a short distance below the cap-rock and having a thickness varying from 5 to 15 feet. The second pay lies deeper in the rock, is thinner and less important than the upper one. The size of shots used in these wells has varied greatly, having naturally been dependent on the nature of the sand. When the latter is coarse and loose, the shots have been small, in some places three quarts only; but when the sand has been found hard and fine the shots have been much heavier, reaching 100 quarts. Some wells in the field have been shot 6 or 7 times; in such cases the first shots have usually been small, and the size increased with the succeeding ones.

The wells on the Ohio side were never great producers of gas, though originally the supply was adequate for operating the territory. The gas, however, decreased more rapidly than the oil, and about 1898 suction pumps were introduced. This greatly augmented temporarily the supply, but even with this method in operation the gas has become so weak that it is scarcely adequate to meet longer the demands of the operator. The staying qualities of the sand, so far as the supply of oil is concerned, varies considerably in different parts of the field. The wells near the Ohio river have lasted better than those farther back. However, by 1898 the operators began abandoning the smaller ones, and in 1901 one company was pulling the casing from all wells that made less than one barrel per day. Another company, however, was still pumping wells that made only one-sixth of a barrel per day. The sand in the territory known as the "Iron Bridge" has given out quicker than that farther south, and although it was not developed until 1895-6, many of the wells had been abandoned by 1901. At one period in 1895 the daily production of the Diest farm was 2,500 barrels; in June, 1901, it was less than 20 barrels. Adjacent farms give similar results. The Keener sand territory around Mechanicsburg has not yet been developed long enough to determine the staying quality of that locality.

The most striking characteristic of the field is the salt-water. It is estimated that the "Pole-Cat" well alone pumped 3,500 barrels per day for weeks. The brine from the hundreds of wells made the creeks salt-water streams, while these emptying into the Ohio made that river brackish at low water. The quantity of brine diminishes to the northwest, and as has already been stated, is not a serious obstacle around the "Iron Bridge" and Mechanicsburg. The mingling of oil, gas and salt-water in the Sis-

PLATE III

VIEW OF THE FORMATION AT BLACK HAND

IN SOUTHEASTERN OHIO THIS BECOMES THE BIG INJUN, KEENER, AND SQUAW SANDS.

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tersville field is ascribed by Prof. White to the flatness of the anticline, the relief not being sufficient to permit the separation of the substances. The top of the anticline is near the villlage Cochransville, on the western edge of the field, and the sand there lies 60 feet higher than it does along the eastern edge of the field. The sand rises to the northwest, lying more than 100 feet higher at the "Iron Bridge" than it does opposite Sistersville, a condition that readily explains the decrease in the salt-water in that part of the territory. Since the summit of the arch lies near the western side of the pool, it follows that the producing territory lies chiefly on the eastern slope, a condition that prevails in nearly every pool in eastern Ohio in which the nature of the anticline has been determined.

Outside of the producing territory, many wells have been drilled with the hope of extending the field. The results have been as follows:

Benton Township.—Three dry holes in the southeastern quarter of section 14 on the John C. Allen farm; one dry hole in the northeast quarter of the same section on the Arch. States land, and one well making a show of oil on the Rosanna Cline land, adjoining the States. One dry hole in the northeast quarter of section 26 on the S. H. Cline farm, and one dry hole near the south line of the same section on the H. A. Williamson land. One dry hole in the northeast quarter of section 32 on the Sarah J. McHugh farm, and one in the southeast quarter of the same section on the Marshall Cline place. One dry hole on the H. A. Williamson farm in the northeast quarter of section 25, also a dry hole on a small lot near the middle of this section. A dry hole on the Cyrus McHugh farm in the northwest quarter of section 19. One dry hole in the northwest corner of section 13 on the Cyrus McHugh land. A dry hole near the south line of section 7 on the Hugh Dines farm. A dry hole on the southwest corner of section 12 on the William Busche place. One dry hole near the south line of section 18 on the T. Stacy land. A dry hole in the southwest quarter of section 30 on the J. C. Lohr farm. A dry hole in the southwest quarter of section 36 on the Sarah A. Knowlton land. A dry hole on the J. W. Lisk farm in the northwest quarter of section 35. A dry hole on the James Swallow land in the southeast quarter of section 29. A gas well on the Joseph Algeo farm in the northwest quarter of section 23. Two gas wells on the J. W. Hensel land in the southern half of section 17.

Jackson Township.—Nearly the whole of this township is occupied by producing territory, and the northern boundary is marked by a series of very small wells rather than by dry holes. On the Joseph Witten farm, near the middle of section 13, a dry hole has been drilled, also one on the William Bowen farm, on the river bank near the eastern margin of the township. One on the Thomas Hissom farm in the southeast quarter of section 26. One on the Hubbard land near the middle of section 20. One on the James Mishnack land in the southwest corner of section 14. One on the V. Voegler farm near the middle of section 33. The narrow strip

of territory extending northeast from the "Iron Bridge" is bounded on each side by a row of dry holes.

Perry Township.—A number of dry wells have been drilled along the margin of the producing territory from the "Iron Bridge" northwest to Mechanicsburg. Outside of this belt the following failures are recorded; One on the M. J. Booth farm near the middle of section 27; one on the William Foraker farm near the north line of section 34; one on the Hobbs farm near the north line of section 10; a dry hole, a small gas well and a small oil well on the J. Hubaker farm in the southeast quarter of section 4; a small oil well on the G. W. Baker farm in the northwest quarter of section 11; two dry holes in section 17, both in the southwest quarter, one on the I. C. Davidson farm, the other on the J. J. Dornbush farm; one dry hole on the S. G. Cox farm near the west line of section 29; one on the J. Drum place in the northeast quarter of section 35; one on the N. Sinclair farm near the eastern line of section 24.

JACKSON RIDGE POOL, (GRIFFITH P. O.)

Location and Area.—This lies chiefly in the southern projection of Center township, but extends southwest into section 30 of Perry and west into sections 31, 32, 33 and 36 of Wayne. On the southwest it approaches within a mile of the Graysville pool, and on the west side within less than a mile of the Moose Ridge pool. Possibly further drilling may connect all three pools, though from the dry holes already found this does not seem probable. The producing territory extends about 42 degrees east of north.

Discovery and Development.—In the spring of 1896 a well was drilled on land of Albert Johnson near Jackson Ridge by the Galey Brothers. A show of oil was found in the Keener sand and considerable gas near the bottom of the same formation. The drill was forced into the Big Injun with the hope of securing a larger production, but that sand was barren. The well was regarded with so little favor that it was not shot until the following year, when it began producing 15 barrels of oil per day. It yielded considerable gas also, which was used in further testing the field. The well is still producing (1901). In the fall of the same year (1896) a well was begun on the Hamilton farm, adjoining the Jackson. It was completed the following winter, probably in January, and began producing 5 barrels per day. The third well was begun on the Nelson Covert farm in the spring of 1897. The oil sand was struck in May, and began producing 25 barrels per day without having been shot. This well attracted oil men from other fields, and soon the Jackson Ridge territory was being extensively tested. Work has been in progress ever since, though it was comparatively quiet when visited in the summer of 1901. It seems probable that much the better part of the territory has been drilled, though work on a smaller scale will probably be done for some time. The number of producing wells in July, 1901, was about 300.

Geology of the Field.—The principal underground formations are shown by the following records, furnished by the Fisher Oil Company:

Well No. 1, George Keller farm:

	Feet.
Top of Cow Run sand	547
"Break" at	740
Bottom of Cow Run sand	940
Top of "Big lime"	1,080
Bottom of "Big lime"	1,214
Top of "break"	1,214
Bottom of "break"	1,220
Top of Keener sand	1,220
Total depth	1,258

The sand marked "Cow Run" can at the most belong in part only to that formation. The lower part occupies the place of the Salt sand, and doubtless constitutes a part of that formation. The term "Cow Run" is often applied by the driller to almost any sand lying above the "Big lime." It is very difficult, if not impossible, to identify this sand in Monroe county, since the principal formations by which it is recognized are the Cambridge and Ames limestones, neither of which is reported by the driller.

Well No. 1, M. Wool farm.

	Feet.
Top of Keener sand	1,406
Bottom of Keener sand	1,446
Top of Big Injun	1,470
Bottom of Big Injun	1,575
Top of Berea grit	1,972
Bottom of Berea grit	1,978
Total depth	2,031

The oil and gas are derived from the Keener sand, though occasionally a show of both is found in the Big Injun. The producing sand has commonly a thickness ranging from 25 to 40 feet, thinning northward and thickening to the south. Frequently the sand is pebbly; especially is this true near the top. The wells are usually shot with from 60 to 100 quarts, but charges reaching 160 quarts have been used. The results of such heavy shots, however, have not been helpful, at any rate they do not seem to have done better than lighter shots would have done. When the wells have been shot a second time, the later charge has usually been heavier than the earlier one.

The Mountain limestone or "Big lime" which lies above the Keener sand is thinner than it is to the south and southwest. According to Mr. A. L. Johnson, of the Fisher Oil Company, it has ordinarily a thickness of 80 feet, but the well records frequently show figures much smaller than this. Occasionally the limestone contains a bed of sand interstratified, and this usually contains salt-water.

Oil and Gas.—On the northwest side of the field much gas is found, the closed pressure reaching 400 pounds in some wells; but elsewhere the quantity is very small, not sufficient in some cases to develop and operate the territory. This has necessitated hauling coal from Safford, near the western edge of the county, more than 10 miles distant. The oil has a gravity of 47 deg. B., and is of excellent quality. The largest wells started at about 100 barrels daily, but the average has been much less than this; however, while the wells do not have usually a large initial production, they do have excellent "staying qualities," making the pool one of the most valuable ones in this part of the state. According to the report of the gauger for the Buckeye Pipe Line Company the 300 wells in the field were making 55,000 barrels per month during the summer of 1901. Salt-water is not abundant, but increases southward, where it adds to the expense of operating the territory. The wells are cased usually to the top of the "Big lime."

Other Wells in Center Township.—Many wells have been drilled in this township with the hope of finding a northward extension of the Jackson Ridge and Moose Ridge pools, but thus far the results have been almost entirely negative. The locations of these wells are as follows: A well making a show of oil on the Ferrenbach land in the northeast quarter of section 12; a gas well on the Short farm near the north line of section 4; a dry hole on the Brubach farm in the northwest quarter of section 5, and one on the Brothers' estate in the northwest quarter of the same section; four wells in section 6, a dry hole near the middle of the section on the Brubach land, a small oil well on the Cooke farm in the southeast quarter; a gas well on the Kerr land in the northeast quarter and a dry hole on the Ferrenbach farm in the northwest quarter; a dry hole on the McCannon farm in the southeast quarter of section 1; a small gas well (now abandoned) on the Holida land in the southwest quarter of section 35; two wells near the south line of section 36 along the B. Z. & C. R. R., one yielding gas and the other some oil; a dry hole on the Clingan farm in the northwest quarter of section 31; two dry holes on the Shumacher farm near the middle of section 23; a dry hole on the Burkhead farm in the southwest quarter of section 20; a dry hole on the Stout farm near the middle of section 16; two dry holes in section 13, one on the Shumacher farm near the east line and one on the Windland farm in the northwest quarter; a dry hole on the Clanges farm in the southeast quarter of section 10; a dry hole on the Mooney farm in the southeast quarter of section 12.

THE GRAYSVILLE POOL.

Location and Area.—This lies almost entirely in Washington township, embracing sections 4, 5, 6, 10, 11, 12, 16 and 17. Beyond this township the pool extends northward into Wayne, where it includes parts of

sections 1 and 7. The productive belt runs 40 degrees east of north, has a length of four miles and a maximum width of two miles.

Discovery and Development.—In the winter of 1895-6 a well was drilled on the Delaplaine farm in section 11, near the village of Graysville. It made a good showing of oil in the Keener sand, but not sufficient, in the judgment of the drillers, to warrant shooting, and so the well was abandoned. However, the test was not regarded as conclusive, and accordingly a second well was soon begun, but this made a poorer showing than the first one, and so was abandoned without having been shot. A third well was completed on the same farm in December, 1897; with results entirely similar to the preceding two. These failures discouraged further exploration, and nothing more was done until 1900, when the Devonian Oil Company drilled a well on the same farm and about 75 yards from the first well. This well was completed in June, and after having been shot with 100 quarts of nitro-glycerine began flowing oil, producing at first nearly 100 barrels per day. The producing sand was the Keener. About one month later a well was drilled on the Eaton farm, adjoining the Delaplaine on the north. This was a success, though not so good as the one previously drilled. These two wells attracted the attention of operators in other fields, and soon the territory was being rapidly developed. The boom lasted during the summer and fall of 1900, but since then comparatively little work has been done. This has resulted partly from the decrease in price of oil, but more largely from the diminution in the size of the wells as the drill moved farther and farther from the center of the productive territory.

Geology of the Fields.—The following skeleton sections show the principal underground formations:

Well No. 1, W. A. Oden farm. Authority, Fisher Oil Company:

	Feet.
Top of Keener sand	1,333
Bottom of Keener sand	1,358
Top of Big Injun	1,380
Bottom of Big Injun	1,540
Top of Berea	1,885
Total depth	1,917

Well No. 1, J. W. Foraker farm. Authority, Fisher Oil Company:

	Feet.
Top of Keener sand	1,439
Top of Big Injun sand	1,485
Top of Berea sand	2,004
Bottom of Berea sand	2,012
Total depth	2,025

The Keener is the producing sand, except in those wells in section 9 and the southern half of section 10 which are reported in the Big Injun

proper. Two small Berea wells are found on the Mann farm in the southern half of section 5.

The Maxton sand, which lies just above the "Big lime," has a thickness commonly ranging from 15 to 30 feet. This is divided into two parts by a bed of slate. Neither of these produce oil or gas in commercial quantities, but when either is reported it is from the upper bed. The "Big lime" or Mountain limestone is from 60 to 100 feet thick, is free from beds of sand and void of oil or gas. The Keener sand does not lie immediately below the "Big lime," but is separated from it by a "break" or bed of slate, having commonly a thickness of 15 feet. The sand rock under consideration varies considerably in thickness, ranging ordinarily from 15 to 60 feet, with the average of these two figures representing the common thickness. The sand is reported pebbly at the top, but the lower part, including the pay, is finer. This character of the producing rock is doubtless responsible for the poor showing of the wells before they are shot, and was the cause of 5 years' delay in opening the field. In view of developments in 1900 it seems certain that had the early wells drilled on the Delaplaine farm been shot they would not have been recorded as failures. The Big Injun sand proper, which lies about 20 feet below the Keener, from which it is separated by a bed of slate, has ordinarily a thickness approximating 125 feet, but there are marked variations from this figure. Lying from 6 to 10 feet below the Big Injun is another sand, known as the Squaw, a name applied to a producing sand in West Virginia by the drillers of that state. A generalized section of these formations in the Graysville field is as follows:

Maxton sand	15 to 30 feet
Mountain limestone ("Big Lime")	60 to 100 feet
Slate ("break")	10 to 20 feet
Keener sand	15 to 60 feet
Slate ("break")	5 to 25 feet
Big Injun proper	100 to 150 feet
Slate ("break")	6 to 10 feet
Squaw sand	8 to 30 feet

As shown by the records previously given, the interval between the top of the Keener sand and Berea grit is about 550 feet. Well No. 16 on the Delaplaine farm is said to have reached a depth of 2,367 feet, the objective point being the Gordon sand, but the search was a failure.

Oil and Gas.—The field, like the neighboring one of Jackson Ridge, produces little gas. The supply, in fact, has been so small that it was not adequate for exploring the territory, and accordingly the driller has been compelled to rely on coal or on gas derived from another field. The wells are not heavy producers of oil, the largest having started at approximately 100 barrels per day. The field has not yet been operated sufficiently long

to determine the "staying qualities" of the sand, but its proximity to Jackson Ridge leads to the hope that the production will be long-lived. In July, 1901, there were 220 producing wells in the field, and these averaged 10 barrels each per day. Along the margin of the pool the production gradually decreases until it becomes so small that the operator will drill no further. Inside of this border the sand is rarely barren of oil, a condition adding much to the value of the territory.

The field is quite free from salt-water, little being found outside of the Salt sand, and the quantity there is not large. The wells are usually cased in the Maxton.

The landholder has usually received a royalty of one-eighth of the oil, but sometimes this has been larger, amounting in a few instances to one-fourth.

THE MOOSE RIDGE POOL.

Location and Area.—This lies west of Jackson Ridge and north of Graysville. It includes sections 2, 3, 8, 9, 14, 20, 26 and 27 of Wayne township. The shape of the pool is that of a right angle, the principal part running north and south, from the latter end of which an arm extends westward, this portion being commonly known as the Rich Fork pool.

Discovery and Development.—The pool was discovered in the fall of 1898 or spring of 1899, the first well having been drilled on the Cronin farm, in the western arm of the field. The well is reported to have started at 125 barrels per day, the producing sand being the Maxton. This well was followed by others with varying results, the sand being found spotted, so that a map of the field shows an admixture of oil and gas wells with dry holes. From this character it is readily understood that the territory is not as valuable as that of Jackson Ridge or Graysville. The dry holes already drilled outside of the pool show that the limits of the latter have now been pretty definitely determined.

That part of the pool running north and south was opened early in 1900, the first well having been drilled on the Bishop land. It is reported to have started producing 25 barrels per day, the oil being derived from the Keener sand. From this farm the drill moved in all directions, work being very active during the summer and fall of 1900. The limits of the field were determined in a few months, however, and since then drilling has been comparatively quiet.

Geology of the Field.—There are three producing sands, a shallow one known as Cow Run, the Maxton and the Keener. The relative positions of these are shown by the following records:

J. Dearth farm, well No. 1. Authority, Fisher Oil Company:

	Feet.
Cow Run sand at	715
Salt sand at	760
Bottom of Salt sand at	840
Top of Maxton sand	955

	Feet.
Bottom of Maxton sand	1,060
Top of "Big lime"	1,090
Top of Keener sand	1,150
Gas at	1,155
Oil at	1,160
Top of Big Injun	1,198
Total depth	1,224

The sand named "Cow Run" is not an important producer. Wells in it have been secured on the Willison, Daugherty and Turney farms, one having started at 25 barrels per day. The sand, however, cannot be the equivalent of the one having the same name found in Washington and Morgan counties. At Joy, in the latter county, the interval between the Cow Run and Salt sands is 470 feet, while in the above section it is 45 feet only. The sand in question might be the Second Cow Run, but it cannot be identified with certainty owing to the absence of any well-marked datum plane, such as a bed of limestone or seam of coal. With the driller the Cow Run sand is almost any one lying above the Salt sand.

The Maxton, which is the oil sand in the western arm of the field, has a thickness ranging from 8 to 100 feet. It is moderately fine, and is shot with from 30 to 80 quarts of nitro-glycerine. The formation is separated from the underlying Mountain limestone by a foot or more of slate. This limestone has a thickness which ordinarily ranges from 60 to 80 feet, is sometimes very hard and at other times soft. The Keener, which is the principal producing sand in that part of the field running north and south, has a thickness ranging usually from 28 to 35 feet. Its structure is similar to that of Graysville and Jackson Ridge. It is separated from the "Big lime" by from 6 to 10 feet of slate. Neither oil nor gas has been found in paying quantities in the Big Injun, and no records of its depth were secured.

Oil and Gas.—In that part of the field running north and south there is a well-defined oil and gas belt, the latter lying west of the former, a condition which doutbless results from the oil sand rising westward. The closed pressure in the gas wells was at first 150 pounds, but one year later had dropped to 60 pounds. The gas has been used for drilling and pumping in this field and Jackson Ridge. The largest oil well started at from 140 to 150 barrels in 24 hours, but the average has been, of course, much less than this. In July, 1901, the average daily production was 9 barrels per well. The oil has a gravity of 46 deg. B.

The oil wells in the western arm of the pool are comparable in size to those just mentioned, and the oil has the same gravity. The wells produce considerable gas, with but little salt-water. The distinctly gas wells in this arm of the field are reported in the bottom of the Keener or top of the Big Injun proper. At first these had a closed pressure of 250 pounds per square inch, but this had dropped to 110 pounds in July, 1901. The gas

wells are not restricted to one side of the field, but are intermingled with the oil wells.

THE WHITACRE POOL.

Location and Area.—This contained in 1901 less than 25 wells, lying almost entirely in section 21 of Washington township. The principal farms were the Whitacre, Hendershot and Martin. The pool lies two miles west of the south end of the Graysville field.

Discovery and Development.—The pool was opened in 1899 with a well on the Whitacre farm. No oil of consequence was secured until the Squaw sand was reached, when there was a fine yield of oil, the well flowing for several days. A well on the Knowlton farm was drilled to the Big Injun sand in the fall of 1899, but this rock being dry, the hole was extended to the Berea in the following spring. This sand was found to have a thickness of 22 feet, and after having been shot with about 20 quarts of nitro-glycerine began producing 6 barrels of oil per day, but this had decreased to 2 barrels in July, 1901. The limits of the producing territory have not yet been determined, but it does not seem probable that the pool will be a large one.

Geology of the Field.—With the exception of the Knowlton well, the producing sand is the Squaw. This lies from 8 to 10 feet below the Big Injun, and has a thickness ranging from 8 to 20 feet. It is usually pebbly, but sometimes becomes fine. The Big Injun ranges ordinarily from 120 to 140 feet in thickness, and one well recorded 170 feet. The wells are small, the largest starting at 30 barrels. The wells now (1901) average 10 barrels each per day. But little gas is produced, necessitating a dependence on coal or gas wells elsewhere for fuel.

In the southern half of Washington township, lying south of the Whitacre and Graysville pools, a number of wells have been drilled, the record of which is as follows: A dry hole on the Jacob Coss farm in the southwest corner of section 2; a dry hole on the S. A. Baker farm in the northeast quarter of section 8; a dry hole on the W. T. Springer farm in the northwest quarter of section 14; a dry hole in the northeast quarter of section 20 on the Winfield Poulton farm; two dry holes in section 1, one in the northeast quarter on the Henry Cline farm, the other in the southeast quarter on the Charles Hill place; two dry holes on the Fred Ullman farm in the southwest quarter of section 7; a dry hole on the land of George Blair in the southeast quarter of section 13; a dry hole in the southeast quarter of section 19 on the farm of Elisha Smith; four dry holes, two small oil and one gas wells near the center of section 6; one dry hole on the land of Martin Cline in the northeast quarter of section 12; a small gas well in the northwest quarter of section 18 on the land of G. W. English; three small gas wells along the southern margin of section 17, near the Washington county line; a dry hole in the northeast quarter of section 23 on the B. W. Piatt farm.

BETHEL TOWNSHIP.

There are two small pools in this township:

1. The Clift;
2. The Sycamore.

The Clift Pool.—This pool was discovered early in 1900, the pioneer well having been drilled on the Clift farm. This well is reported to have started producing 85 barrels from a sand lying in the "Big lime." The latter is not the homogenous formation in this field that it is farther east and south, but, according to reports of drillers, is divided near the middle by a heavy stratum of sand, and it is this which yielded the oil of the well referred to, and that of other wells in the vicinity. However, there are several wells in the Big Injun and occasionally a little oil is derived from the Keener. The number of producing wells in the pool is less than 20. The general succession of formations is as follows:

G. W. Martin farm, well No. 1:

	Feet.
Cow Run sand at	600
"Big lime" at	1,033
Sand in "Big lime" at	1,066
Bottom of latter at	1,100
Top of Big Injun at	1,185
Berea sand at	1,810

The Sycamore Pool.—The Sycamore pool, as developed in August, 1902, formed a narrow strip about two miles long. The number of wells completed was about 20, but ten strings of tools were at work and the number of wells is now doubtless larger.

According to William Longfellow, an experienced driller, the oil is obtained from the Keener sand. The "Big lime" ranges in thickness from 60 to 80 feet. Some salt-water is found in the Maxton sand, but very little in the Keener. The casing extends to the "Big lime."

Other Wells in the Township.—In the northern half of section 35 two gas wells have been drilled on the Wineland farm, one dry hole and one small oil well on the Bode farm, and an oil well on the lot just south of the Wineland place; a dry hole on the Lindmood farm in the southeast quarter of section 5, and a show of oil in a well on the Bode farm in the northeast quarter of the same section; a small oil well on the Anderson farm in the northwest quarter of section 28, and a dry hole near the center of the same section on the C. D. Hartshorn place; a dry hole on the Unger farm in the northwest quarter of section 3, and one on the W. M. Martin farm in the southwest quarter of the same section; a small well on the Smithberger farm in the northwest quarter of section 26; a dry hole on the Park's farm in the northeast quarter of section 2; a dry hole on the Simmons farm in the southeast

quarter of section 25; a dry hole on the Stewart farm near the west line of section 7.

MINOR POOLS IN OTHER TOWNSHIPS.

Franklin Township.—In the extreme southeast corner of this township a half-dozen oil wells have been secured on the Wineland and adjacent farms, the producing sand being in some cases the Big Injun and in others the Keener. The first well was drilled in the fall of 1899, and began producing 5 barrels. One well has been drilled which had an initial proudction of 50 barrels per day. The sands produced considerable gas. Other deep wells in the township are as follows: One dry hole on the C. Hines farm in the northeast quarter of section 6; a dry hole on the T. Hines farm in the southwest quarter of section 3; a show of oil on the Wilson farm near the north line of section 1; a dry hole on the Okey farm in the northwest quarter of section 2, and a gas well in the southwest quarter of the same section; a gas well on the Carpenter farm in the northeast quarter of section 8; a dry hole on the King farm in the southwest quarter of section 14; two dry holes on the Renner farm near the east line of section 20, and one dry hole in the southeast quarter of the same section.

Green Township.—Two pools of oil have been found in this township, the Newcastle and the Benwood. The Newcastle pool extends slightly east of north and includes parts of sections 31, 32, 33, 27 and 28. Oil was discovered in 1890, the first well having been drilled on the Stevens farm. The production from this well was not large, and owing to poor shipping facilities was soon abandoned. The next well was on the Neff farm, adjoining the Stevens, and was a dry hole. Not until 1894 did work begin in earnest. In that year the greater number of wells were drilled and the limits of the pool pretty definitely determined. The Berea is the producing sand. It has a thickness ordinarily ranging from 10 to 16 feet, but sometimes disappears entirely. From this it follows that the territory is spotted, the producing wells and dry holes intermingling. On the west side of the field considerable gas is found, which is used, not only to operate this field but the Benwood as well. The oil is black and has a gravity of 41 deg. B., commanding 25 cents less per barrel than that of the other pools in the county.

The Benwood pool lies about one and one-half miles east of the Newcastle, with which it runs parallel. It occupies parts of sections 25, 26, 20, 21 and 15. At its greatest development the pool has a width of two-thirds of a mile, but usually the width is much less than this. The field was opened in the fall of 1894, the first well having been drilled on the Holtsclaw farm. This well produced little oil, but made considerable gas. The following summer a well was drilled on the Price farm, adjoining the Holtsclaw. This produced 150 barrels of oil the first day, and of course at once started great excitement. The largest well in the field is Neff No. 2, which started at 1,400 barrels. Other fine wells have been

secured, but the production has declined rapidly, the sand, which is the Big Injun, not possessing good "staying qualities." In July, 1901, by far the greater number of wells had been abandoned. In the northern part of the field many dry holes have been drilled, and this fact, coupled with the short life of the wells, has made the field an expensive one to the operators. The underground succession is shown by the following record of Holtsclaw well No. 3:

	Feet.
Coal at	410
Thickness	6
Cow Run sand	950
Thickness	35
Salt sand at	1,250
Thickness	125
"Big lime" at	1,470
Thickness	40
"Break" (slate) at	1,540
Thickness	16
Big Injun sand	1,556
Thickness	71
First "pay" at	1,570
Second "pay" at	1,595

Adams Township.—The first deep well in this township was drilled in 1887 or 1888 on the land of George Suppes, near the village of Cameron. A flow of oil is reported to have been struck in the Big Injun sand, but the oil was accompanied by a heavy flow of salt-water, which discouraged the operators so far as the Big Injun sand was concerned, and accordingly they determined to drill on to the Berea. This was found at a depth approximating 2,000 feet, but was dry. The well stood idle during four or five years and then was pumped for a short time, and finally abandoned. No further testing seems to have been done until 1896, when another well was drilled on the same farm. A 15-barrel producer was secured in the Big Injun sand, but later when the well was shot a second time a large flow of salt-water was liberated, and this ruined the well. During the years 1896-7 work in the field was quite active, the testing being done principally in sections 13, 14, 18 and the half-section lying east of 13 and 18. Several good wells were secured; one on the Mobley farm in the northeast quarter of section 13, drilled in 1897, started at 160 barrels per day, and is still producing; another large well was Greathouse No. 2, lying east of the Mobley, and starting at 130 barrels. The sand, however, was soon found to be very spotted, and the production of oil short-lived. As late as 1902 a well was drilled occasionally, but it does not seem probable that much work remains to be done in this locality. All the producing wells are in the Big Injun sand, the oil being derived near the top, while further down brine is encountered. The Maxton and Keener sands are recognized, and each occasionally makes a show of oil.

Outside of the Cameron field a number of wells have been drillled in this township; a dry hole on the Bracy farm in the southeast quarter of of section 31; a dry hole on the Vanert farm in the southeast quarter of section 26; a dry hole on the Pfalzgraff farm in the southwest quarter of section 19; a dry hole on the John Winkler farm in the northeast quarter of section 17.

Salem Township—A number of deep wells have been drilled in this township, but thus far neither oil nor gas has been found in marketable quantities. The locations of the wells are as follows: One on the Henthorn farm in the southeast quarter of section 7; two in the eastern half of section 12, one on the Boughner and the other on the Maurray farm; one on the Ward land in the southwest quarter of section 8; one on the Arn land in the northwest quarter of section 35; one on the Yost farm in the northwest quarter of section 30. It is probable that all these wells reached the Big Injun sand.

Summit Township.—Drilling in this township has been largely confined to two localities, (1) on the Ludwig and Matz farms in sections 19 and 25, and (2) on the Wise and adjacent farms about one mile east of Lewisville.

A well on the Matz farm in section 25 was completed December 26, 1900, and started at 8 barrels; in July following the production was 5 barrels per day. Early in the spring of 1901 a well was drilled on the Ludwig farm, which adjoins the Matz on the east. The production was at first about 75 barrels per day, and was 25 barrels in July of the same year. The oil is reported to have been derived from a sand in the "Big lime." Besides the 2 producing wells in this locality on July 1, 1901, 4 wells had been located, and three dry holes drilled, one on the Friday farm in the northeast quarter of section 30, and two in the southwest quarter of section 19 on the Konig and Black farms.

The territory east of Lewisville was opened in 1899, the first well having been drilled on the Wise farm. This began producing 10 barrels per day, but soon dropped to 2 or 3 barrels and was abandoned in the summer of 1900. The same year a well was drilled on the Diehl farm, adjoining the Wise, but was dry. The first good well in the field was drilled in the spring of 1901 on the Wise farm, and is reported to have begun producing from 75 to 100 barrels per day from a sand in the "Big lime." About the same time another well was drilled on the same farm by Galey Brothers & Mooney, which started at 100 barrels per day. On July 3, 1901, a well was completed on the Sperry farm which started at 300 barrels per day, and produced over 9,000 barrels of oil the first month, and 60,000 the first year. This well has been a remarkable producer. It was reported to be yielding 60 barrels per day in August, 1902. Several wells were later drilled on the same farm, and all were small producers, starting at from 25 to 75 barrels per day. Just before the large well above referred

to was completed the drillers, Galey Brothers & Mooney, sold a half interest in it to Roy Brothers for $1,600, about the cost of the well. The oil is reported from a sandstone lying beneath from 10 to 15 feet of lime-rock, which is presumably the "Big lime." On this basis the sandstone is the Keener. The small thickness of the "Big lime" is in harmony with what has been stated elsewhere, viz; it thins rapidly to the west and is soon replaced by sandstones and shales.

The general succession of strata is shown by the following record:

F. C. Neuhart well No. 1, located about two miles northeast of Lewisville. J. M. Guffey & Co., owners. Data furnished by George Troutman:

	Thickness of stratum. Feet.	Total depth. Feet.
Conductor	12	12
Slate	20	32
Sand, white	40	72
Slate	27	99
(88*ft.* 10 *in. casing.*)		
Lime	12	111
Slate	14	125
Lime	7	132
Red rock	13	145
Slate	27	172
Lime	20	192
Slate	43	235
Sand	10	245
Coal	2	247
Slate	12	259
Lime	22	281
Slate and sandy shale	46	327
Slate and lime	30	357
Sandy shale	43	400
Red rock (called "Big red")	100	500
Sandy shale	21	521
(500 *ft.* 8*in. casing.*)		
Red rock	40	561
Slate	50	611
Red rock	15	626
Slate, white	21	647
Slate, black	53	700
Sand, First Cow Run	45	745
Slate—gas at 755 ft	10	755
Sand, Second Cow Run	60	815
Slate	5	820
Sand (Salt Sand)	105	925
Coal	4	929
Slate, white	29	958
Sand, gray	103	1,061
Slate, black	20	1,081
Sand, white	15	1,096
Sand, black	20	1,116
Slate, black	9	1,125

	Thickness of stratum. Feet.	Total depth. Feet.
(1,125 *ft.* 6¼ *in. casing.*)		
Slate, black	40	1,165
Sand, gray	33	1,198
Slate, black	3	1,201
Sand, white	29	1,230
Sand, black	29	1,259
Sand, white	20	1,279
Lime (called "Big lime")	36	1,315
Slate	30	1,345
Sand, Keener	42	1,387
Slate	3	1,390
Sand, Big Injun	170	1,560
Slate	20	1,580
Slate and shells	275	1,855
Sand, gray	10	1,865
Slate, black	57	1,922
Sand, Berea	4	1,926
Slate	30	1,956

Outside of the two localities already described a few wells have been drilled in the township; a dry hole on the Buchanan farm in the southwest quarter of section 18; a dry hole on the Young farm in the northwest quarter of section 13; two wells in the southeast quarter of section 29, a dry hole on the Denbow farm and one making a little oil on the Webb farm.

Malaga Township.—In the winter of 1901-2 a small pool was opened in section 36, less than two miles west of Jerusalem. The first well, which was drilled on the Harper farm, is reported as having begun producing oil at the rate of 300 barrels per day. By August, 1902, nearly a dozen oil wells had been completed, and a few gas wells. The pool extends into Belmont county, though at the time the territory was visited only one oil well had been secured north of Malaga township.

The "Big lime" in this field is reported 40 feet thick. About 20 feet below it the Keener is found, and this contains the oil. The upper part of this formation is reported pebbly, and the lower portion a sandstone. Oil is found in the upper part and salt-water below. The limits of the field have not yet been determined.

Outside of this pool a number of wells have been drilled; two dry holes in the northwestern part of section 30; one dry hole in the northeast corner of section 35; two dry holes in the southern part of section 28; one dry hole in the southern part of section 33; one dry hole in the southeastern part of section 4; one small gas well in the southeast quarter of section 3; one dry hole in the southeast corner of section 6, and two oil wells in the southwest quarter of the same section; one dry hole in the southeast corner of section 10; one gas well in the southeast quarter of section 16; one gas well in the southeast corner of section 21; one gas well in the northeast

quarter of section 35; and one dry hole in the southeast quarter of section 29.

Scattering Wells in Other Townships.—In Seneca township two deep wells have been drilled, a dry hole near the middle of section 5, and a gas well in the southwest corner of section 24. In Sunbury township more than a dozen deep wells have been drilled in the western half of the township. They are located in sections 5, 10, 15, 16, 18, 21, 23 and 24. All are dry holes except three in section 24, which make some gas. In Ohio township several deep wells have been drilled, a dry hole and a well making a show of oil on the Muhlman farm near the north line of section 14, a dry hole on the Kesserman farm in the northeast quarter of section 32, a well making a showing of oil on the Winkler farm in the southeast quarter of section 7, a dry hole on the Fisher farm near the south line of section 30, and a dry hole in the valley of the Ohio on the Bridgman farm in section 23. In Lee township a dry hole has been drilled in the northeast corner of section 23, and a well producing gas on the Goddard land in the southeast corner of section 11.

BELMONT COUNTY.

A large amount of drilling for oil and gas has been done in this county, but the results have not been commensurate with the labor and money expended. No large area in the county remains untested, and hence it is unreasonable to expect that extensive tracts of producing territory will be discovered, though small but valuable pools or reservoirs may yet be found. The surface rocks belong largely to the Monongahela formation or Upper Productive Coal Measures. Of the pools already found the following deserve special mention:

1. Barnesville;
2. Temperanceville;
3. Colerain.

THE BARNESVILLE OIL AND GAS FIELD.

This lies immediately west of the city limits, and extends northeast and southwest. It has a length of two miles and a maximum width of one mile.

The first deep well in the vicinity of Barnesville is reported to have been drilled early in 1887, the expense having been met by the city which, under authority from the Legislature, had bonded itself for $5,000. The search appears to have been begun for gas rather than for oil, which was desired for the glass factory and for domestic purposes. The well, as reported by Dr. Orton, had a depth of 2,700 feet, the Berea having been struck at about 1,600. The Berea made a little oil and considerable salt-water, and so must be assigned to the long list of failures. This, however, did not discourage the citizens, and on March 25, 1887, the Warren

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Oil and Gas Company was incorporated with a capital stock of $5,000, divided into shares of $100 each. On May 1, 1889, this was increased to $25,000, and on January 16, 1894, the company voted to increase the stock to $100,000 for the further development of the territory. This company located its first well southwest of town on land of William Barlow, February 20, 1888. The Berea sand was found but made a show only of oil, and the second well produced similar results. Before making further exploration the company employed Mr. F. W. Minshall, of Marietta, to examine the field. He reported a low arch northwest of town, and in 1889 a well was located by him on the Parker farm on this arch. The result was a gas well having a closed pressure of 640 pounds, and a daily production of 750,000 cubic feet. Another well was soon drilled on the same property with results similar to the first one. In 1890 Dr. Orton measured these wells and reported that they produced conjointly 800,000 cubic feet per day. The gas was piped to Barnesville the same year. In 1891 two wells were drilled on the Laughlin farm, adjoining the Parker, and both were fair gas wells.

From what has just been said it is apparent that during the early years the territory produced gas only. Early in the winter of 1893 a well drilled on the Parker farm east of the gas wells began producing 25 barrels of oil per day, thus proving the existence of oil as well as gas in commercial quantities. Drilling has been in progress in the field from time to time since that date. In August, 1901, the daily production was reported by the guager to be 175 barrels per day. In December, 1902, the 25 oil wells of the field were producing from 30 to 35 barrels in the same period. The gravity of the oil was reported by the guager to be 46½ degrees B. As soon as oil was discovered the Buckeye Pipe Line Company entered the field and began shipping the product in tank cars, but in 1895 it laid a pipe line to Sistersville, West Virginia.

In 1898 the Warren Oil and Gas Company sold its gas wells to Treat and Crawford, and in 1899 its oil wells. Gas is furnished to about 500 customers and to two glass houses (July, 1901), but the local supply is increased from the Dudley field, in Noble county. The price of gas was at first 10 cents per thousand cubic feet; in 1897 it was doubled, but opportunity is afforded to reduce this 5 per cent. by paying the bills before the 10th of the month.

The following figures show the daily production in cubic feet of the oldest gas wells at different periods during the first five years of their history:

	1889 (when first drilled).	April 26, 1892.	April 20, 1894.	April 26, 1895.
Parker No. 1.....	750,000	66,703	.....	.....
Parker No. 2.....	750,000	174,364	99,960	71,665
Laughlin No. 1....	.....	266,804	142,800	100,378
Laughlin No. 2....	.....	159,966	95,166	50,000

The oil and gas are derived entirely from the Berea grit, which is found in almost every well, and in normal conditions. The gas pressure is generally sufficient to flow the wells, and this has diminished the cost of operating them. As has already been stated the producing territory forms a low anticline.

THE TEMPERANCEVILLE FIELD.

This lies in Somerset township, Belmont county, and Beaver township, Noble county. It lies due north of Temperanceville, and extends north and south. As developed in July, 1901, the length of the field was two miles and the width one mile.

The pool was discovered in December, 1899, the first well having been drilled on the Pfeffer farm. This began producing 17 barrels per day, and in July, 1901, was producing 10 barrels daily, indicating that the production will be long maintained. From that time drilling has been done, though not with great rapidity, owing in part to the producing territory belonging to one company. Twenty-seven wells were drilled in the pool by July 15, 1901, and of these only two were dry, but the two at the south end of the field were so small that they were almost valueless. Only one gas well had been drilled when the field was visited, and that lay on the extreme west side. The best oil well in the pool started at 35 barrels per day. The few dry holes found justify the hope that the producing territory may be considerably extended. The Berea grit is the producing rock. The production of the pool in July, 1901, was 175 barrels per day. Like the Barnesville field nearly all of the wells flow. The gravity of the oil was reported by the guager for the Buckeye Pipe Line at 40½ degrees B. The oil is pumped to Sistersville. In November, 1902, there were 28 wells in this field, the daily production being 110 barrels.

The following record of Pfeffer well No. 1 shows the general underground succession. The head of the well is reported to be at the level of the Pittsburg coal. Data furnished by S. B. Hughes, representative of the J. M. Guffey Company:

	Feet.	Feet.
Soil	5	5
Lime, blue, hard	50	55
Slate, red, soft	105	160
Slate, white, soft	20	180
Slate, red, soft	210	390
Slate, black, soft	30	420
Lime, gray, hard	10	430
Sand, white, soft	50	480
Slate, black, soft	10	490
Sand, gray, soft	8	498
Lime, white, medium	42	540
Sand, white, soft	80	620
Slate, black, soft	73	693
Sand, white, soft	44	737
Slate, black, soft	68	805

	Feet.	Feet.
Salt sand, white, soft and hard	166	971
Slate, white, soft	3	974
Lime, white, medium	24	998
Slate, white, soft	20	1,018
Big Injun sand	232	1,250
Slate, black, soft	3	1,253
Sand, gray, hard	43	1,296
Slate, blue, soft	6	1,302
Lime, brown, hard	8	1,310
Slate and shells, blue, soft and hard	80	1,390
Slate, blue, soft	75	1,465
Lime, gray, hard	15	1,480
Slate, black, soft	44	1,524
Lime, black, hard	9	1,533
Slate, black, soft	12	1,545
Lime, gray, hard	25	1,570
Slate, black, soft	52	1,622
Berea sand, white	9	1,631

The following is a skeleton record of a well drilled on the Legler farm near Temperanceville in the early summer of 1901. Data furnished by the Sun Oil Company:

	Depth. Feet.	Thickness. Feet.
Top of Salt sand at	840	40
Top of Keener sand at	1,000	30
Top of Big Injun sand at	1,060	215
Top of Berea grit at	1,600	12
Shales		588
Total depth of well	2,200	

It was hoped that by drilling below the Berea grit one of the deeper sands found in a neighboring state might be struck, but the effort, like all others in Ohio having that object in view, was a failure.

The Pittsburg coal in this vicinity has a thickness of 4 feet. Drillers report a six-foot seam about 400 feet lower. This is probably the Upper Freeport coal. No well record was available, however, showing the relative positions of the two seams, and the figure just given may not be even approximately correct.

THE COLERAIN OIL FIELD.

This lies in and adjacent to the village of Colerain in the township of the same name, situated in the northeast corner of Belmont county. The productive territory is less than one mile in length, and about one-fourth of that in width. It includes a small part of sections 7, 8, 13 and 14.

The first well was drilled in 1894 on land of John Starbuck in section 7. The Berea sand is reported to have been struck at 1,872 feet. The well began producing 30 barrels of oil per day, and was not abandoned until 1899. It produced much gas and flowed for some time. The second well was drilled on the Sharkey farm, and had an initial production of 125

barrels per day. It was shot with 60 quarts of nitro-glycerine, and was not abandoned until 1900. The best well in the field was drilled on the Brackin farm, and is reported to have flowed 1,000 barrels of oil the first 48 hours, and to have averaged 300 barrels during the first 90 days. In July, 1901, the well was producing 10 barrels per day. In 1895-6 several dry holes were drilled, the result of which was to check exploration. It was soon found that the productive territory was very small, and further that the wells were short lived. Of the 30 wells drilled 18 were productive, but 3 only of these were producing in July, 1901. The heavy gas pressure gave the wells a geyser like character which did much to make the field notoriety. The collapse of the boom was almost as sudden as its rise. The operators in the field were:

Thompson & Gasmire,
The West Virginia Gas Co. & T. N. Barnsdale.
The Ohio Oil Company,
The Barton Oil Company,
C. D. Hogg & Company.

The oil was similar to that found at Barnesville and Temperanceville, and commanded the Pennsylvania price. The oil was derived entirely from the Berea sand, which has a thickness ranging usually from 30 to 40 feet. It varies considerably in texture, being sometimes fine and hard, and at other times coarse and soft. The good wells were found where the latter condition prevailed, the fine compact sand being as a rule dry. The interval between the Pittsburg coal and the Berea grit is reported to be 1,555 feet.

OTHER DEEP WELLS IN BELMONT COUNTY.

Wayne Township.—On the Bucher farm in section 32 a well was drilled to the Berea grit in 1900. After having been shot the well made a good showing of oil, but was never pumped and was abandoned. In 1901 a well was drilled to the Berea grit on the Barnes farm in section 28. The results were similar to those in the Bucher well.

Goshen Township.—On the White farm in section 33 a Berea well was drilled a few years ago. It made some gas with considerable salt-water, and was abandoned. On the Allen Bailey farm in section 32 a Berea well was drilled several years ago. It is reported to have made sufficient gas to throw the salt-water over the derrick. The gas was never used and the well was abandoned. A deep well has been drilled on the Warrick farm in the same section. It made a show of oil and gas in the Big Injun and a small show of oil in the Berea. On the Silas Bailey farm in section 31 a Berea well was drilled in 1900. The sand was 30 feet thick, but produced nothing but salt-water. In the spring of the same year a well was drilled to the Keener sand on the McNichols farm in section 32. The well was dry.

Kirkwood Township.—A well was drilled to the Berea grit on the White farm in section 30 a number of years ago. A show only of oil was reported, and the well was abandoned. On the Taggart farm in section 20 a Berea well was drilled in 1900. It made a show of oil and was abandoned. A well was drilled to the Berea on the Ann Drennan farm in 1900. It made some gas, but was abandoned.

Richland Township.—On the John Carlisle farm in section 5 two wells were drilled in 1900. One went to the Berea and the other to the Big Injun sand, but both were failures. A Berea well was drilled on the Chambers farm in section 2 in 1900, but the well was dry. On the Sutton farm in section 28 a well of unknown depth was drilled about 1896, but it was dry. On the Patton farm in section 23 a deep well was drilled, perhaps 10 years ago, but was dry. On the Milligan land in section 2 a Berea grit well was completed early in 1900. It is claimed that this well started at 25 barrels of oil per day, but it was soon abandoned. A deep well was drilled on the Neff farm in section 26 some years ago. It was a failure. In section 31 nine or ten Berea wells have been drilled. The first one was on the Stitt farm, and was drilled perhaps 12 years ago. It produced some oil and was pumped several years. In all, four producrs were secured in this section. On the Clark farm in section 35 a Berea well was drilled about 1893, but was dry. On the Marshall farm in section 34 a Berea well was drilled about 1896, but it was dry. This is said to be the oldest well in the township. On the Burtoff farm in section 22 a Berea well was drilled in the spring of 1900, but was dry.

Smith Township.—In section 6 two deep wells, both dry, have been drilled. One was on the Mary Sutton farm, and the other may have been on the same place.

Pultney Township.—On the Wallace farm in section 6 a deep well was drilled in 1885. The Berea grit was struck at 1,550 feet and produced some gas, but not sufficient for commercial purposes. The well was afterwards extended to a depth of 2,700 feet, but with negative results. A well was drilled on the Reese farm in section 1 about 1896, but this, too, was a failure.

Pease Township.—A deep well, which was a failure, was drilled at Martin's Ferry about 15 years ago, and has already been reported.[1]

An outline of the well record is given below:

	Feet.
Limestone	845 to 855
Salt sand and Big Injun	855 to 1,135
Berea grit	1,530 to 1,660
Bedford shale	1,660 to 1,745
Ohio shales	1,745 to 2,300

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 405.

Two additional wells, both failures, are reported in this township; one on the Thoburn farm in section 31, which went to the Berea sand, and the other on the Parker farm in section 1.

Washington Township.—Five wells have been drilled on the Isaac Welsh estate in section 11. The first two were drilled some distance below the Berea, which was found at about 1,700 feet. Number 1 showed some oil in the top of the Berea, but two or three feet lower a large quantity of salt-water was encountered, and this ruined the well. The Berea was about 25 feet thick. Number 2 did not show more than 8 feet of sand, and this contained a little oil. Number 4 made a good showing of oil in the Big Injun, but the Berea was dry. From 25 to 30 barrels of oil were pumped from the Big Injun sand in one week. The total depth of the well was 1,761½ feet. Well No. 5 made a good showing of oil in the Big Injun, but No. 6 did not do even that. In the fall of 1888 John McKeown drilled a well on the Armstrong farm in section 16, a record of which is given below:

	Thickness of formation. Feet.	Total depth. Feet.
Soil	10	10
Hard rock	20	30
Slate	20	50
Coal, Meigs Creek, No. 9	4	54
Slate	20	74
Limestone, hard, flinty	80	154
Coal, Pittsburg, No. 8	6	160
Slate, blue	30	190
Rock, red	25	215
Slate, blue	40	255
Rock, red	155	410
Slate, blue	100	510
Slate, blue with occasional sandy streaks	400	910
Sand, soft, gray	100	1,010
Salt sand, white, hard, changing to blue	158	1,168
Slate	8	1,174
Big Injun sand	319	1,493
Slate	130	1,623
Sand, hard	25	1,648
Slate, white	25	1,673
Sand and slate, soft	25	1,698
Slate, blue and gritty	124	1,822
Berea sand	16	1,838
Sand, coarse, black and very soft	16	1,854
Slate, red and sandy	60	1,914
Slate, dark, gritty	150	2,064
Sand	15	2,079
Slate, blue	50	2,129
Sand and shale, dark gray	75	2,204
Sand	30	2,234

Some gas was found at a depth of 20 feet in the Salt sand, and much salt-water at 100 feet. Salt-water was found in the upper part of the Big Injun sand, and a show of oil near the middle of the formation. The Berea was dry. In no other well thus far drilled in Ohio has there been reported the well defined sand beds below the Berea that were found in this well. These strata, however, produced neither oil nor gas. A well drilled on the Hendershot farm in section 9 made a small show of oil in the Big Injun. The toal depth of this well was about 1,450 feet. Wells have been commenced, but owing to accidents have not been completed on the Vanduyne farm in section 4, the Bright farm in section 27 and the Workman farm in section 19. For the information concerning this township the Survey is indebted to Hon. E. B. Armstrong.

Yrok Township.—A well has been drilled on the Dorsey farm in section 27, and reached a depth of 2,200 feet. The sand was reported of fine quality. It made a show only of oil, but contained much salt-water. Two deep wells have been drilled in section 20, one on the Boyer farm reaching a depth of nearly 2,300 feet, and making a good showing of oil, and the other on the Dorsey and McMurray farm reaching a depth of 2,200 feet, but entirely dry. A dry well having a depth of 2,100 feet has been drilled on the Ramsay farm in section 8. On the Dorsey heirs farm in section 2 a deep well has been drilled. The depth of this has not been learned. It is claimed to have made a good showing of oil. For the facts concerning this township the Survey is indebted to A. A. Caldwell, of Captina.

Wheeling Township.—In 1902 two wells were drilled near the village Uniontown, and each made a good showing of oil, and with it much salt-water. The Berea sand was found in one at a reported depth of 1,546 feet and in the other at 1,610. The oil was of inferior quality, and the wells were abandoned.[1]

GUERNSEY COUNTY.

The exploration for oil and gas in this county has been long continued and extensive. As stated by Dr. Orton in Volume VI, the search about Cambridge was more than ordinarily interesting. This resulted from the presence at that place of the Cambridge anticline, and hence of the existence of the rock structure regarded as very favorable for oil and gas accumulation. Drilling began about the time of the greatest excitement at Findlay and adjacent towns favorably situated in the great Trenton limestone field, and has been continued from time to time to the present day.

A thorough test has been made of the anticline at Cambridge, and also north and south of this place. The results have been unfavorable. The Berea sand has been struck many times and found to have a thickness and texture suitable for oil and gas, but notwithstanding the favorable

[1]Since the above was written a small pool of oil has been developed in this locality.

combination of these circumstances the products desired have been conspicuous either by their absence or are present in such small quantities as to be of little value commercially.

On the Waller farm near Cambridge 7 shallow wells were drilled, which produced a small amount of oil, but were abandoned. The oil is said to have been of such a nature that the Standard Oil Company would not handle it. The Cambridge Light and Fuel Company has 3 producing gas wells in Cambridge township. These were drilled several years ago, prior to 1892. The rock pressure at present (1900) is reported to be 400 pounds, but the production of the wells about 100,000 cubic feet only per day. There is considerable trouble from salt-water and it is estimated that when the pressure drops to 200 pounds the wells will have to be abandoned. A small oil well was secured in the Berea sand on the Black farm, West Cambridge, in 1899. The sand was struck at 1,098 feet below the surface, and the gas pressure was sufficient to flow the oil. Such discoveries as this simply lead the operator to make further and further tests with the hope of securing a valuable pool.

While expectations have not been met around Cambridge, a valuable reservoir of gas has been found 4 miles south of that city in Jackson township. This is known as the Harmony field. It was opened in 1892 by the Pebble Rock Oil and Gas Company, the first well having been drilled on land of Margaret Murray. The well was closed until 1893, when it, together with all the leases held by the same company were bought by the Cambridge Light and Fuel Company. The latter now has 6 producing wells in the field. Later the United Gas Company extended the territory and now (September, 1900) has 8 producing wells. The Campbell and Buckett Oil and Gas Company has 4 wells in the field, the product of which is piped to Byesville where it is used as a fuel by the Art Glass works. Doubtless other wells will be drilled and the production of the field correspondingly increased.

The Harmony reservoir lies on a low dome shaped uplift. This is made plain by the Cambridge or No. 7 coal which rises above drainage in the central part of the territory, but dips away in all directions from this. It was the existence of this dome which led to the drilling of the first well, and thus to the discovery of the reservoir. The gas sand is the Berea, and lies from 1,080-85 feet below the Cambridge coal. It is not a continuous bed of sandstone, but is separated by a few feet of slate as follows:

	Feet.
Sandstone (gas)	40
Slate	4
Sandstone	20

The gas is found above the slate. At the junction of the gas sand and the slate water is encountered, and so the former is rarely drilled through. Occasionally a little oil and gas are found in the sand below the slate, but none of the wells in the Harmony field derive their supplies from

this horizon. The sand varies considerably in structure. Sometimes it is coarse and porous, and at other times fine and hard. The wells are shot ordinarily with from 25 to 30 quarts of nitro-glycerine. The rock pressure of the field was originally about 500 pounds, but has now decreased to approximately 400. The largest wells produce from 1,000,000 to 2,000,000 cubic feet per day.

The Cambridge Light and Fuel Company charges 15 cents per thousand for the gas. Besides a large number of families the company supplies the local plant of the American Steel Sheet Company, which uses about 2,000, 000 cubic feet per day. The Cambridge Art Pottery Company, now in process of erection, expects to use gas, thus making another large draft on the field. The United Gas Company makes the same rate as the Cambridge. It supplies Cambridge, Byesville, Pleasant City, Hartford, Quaker City, Barnesville and Caldwell. However, several of these places derive their supply from the Dudley field. This company supplies the water works and electric light plants at Cambridge, and the glass houses at Quaker City and Barnesville.

Since the above was written in 1900, much drilling has been done in the Harmony field, with the result that the territory has been considerably extended. Later wells, however, were small, and the heavy demands have greatly decreased the rock pressure of the field. The supply is no longer adequate for the factories, and the same is true for domestic purposes. Had the fuel been restricted to the latter use the supply would have been ample for years.

Besides the exploration around Cambridge and in the Harmony field a large number of deep wells have been drilled in other parts of the county. These are as follows:

Londonderry Township—One Berea well in section 2, making 4 barrels of oil per day.

Jackson Township.—Two Berea wells on the Siens farm in section 7. Both are small producers.

Town of Senecaville.—About 1897 a well drilled at the edge of this village found oil at a depth of 162 feet. It produced 10 barrels the first day and none thereafter. The oil was sold as a lubricant. Other wells were drilled in the same vicinity, but all were failures. Many years ago a shallow well was drilled along Seneca creek, and the oil secured sold as "Seneca oil."

Quaker City.—A well was drilled to the Berea in 1886. The sand was found at a depth of 1,341 feet, and was 6 feet thick. It produced a small flow of gas. Other wells have since been drilled in the same vicinity but without securing returns that compensate the operator.

Kimbolton.—Two wells have been drilled near this place, one in 1887 and the other soon afterwards. The first was a failure, but the second produced a moderate flow of gas, the rock pressure having risen to 300 pounds or more.

NOBLE COUNTY.

The discovery of oil in this county, as in several others in the state, resulted from drilling for salt. Early in the nineteenth century, perhaps in 1814, a well drilled to the depth of about 350 feet on the Caldwell farm, now the Moore, near the county seat, found a supply of oil. This discovery, however, was made too early; for at that time there was no demand for the product, which, in fact, was regarded as a nuisance, since no well in which it was found could be used for salt. The well in question is reported to have flowed periodically, and the oil to have been used for lights and as a lubricant, but it was too thin for the later purpose. It is probable that other wells in the same vicinity gave similar results, but the oil secured was a matter of accident. Not until the discovery in Pennsylvania, in 1859, did the search for oil begin. In that year George J. Duff, of Pittsburg, began leasing land along Duck creek. The first territory secured is said to have been at Dexter, where there was a show of oil in the creek. Later he leased the land near Caldwell, that contained the old well. Most of the leases written at that time guaranteed the land owner a royalty of one-fourth of the oil secured.

About 1860 drilling began along Duck creek between Caldwell and Macksburg. Just east of Caldwell two small, but valuable producers were secured. One of these is reported to have been 98 feet deep, and to have produced oil of 26 degrees B. gravity. The depth of the second well is not definitely known, but it is reported to have been deeper than the first one, perhaps from 250 to 300 feet. The gravity of the oil secured from this well was 34 degrees B. The product was hauled in barrels to Lowell, and then shipped by boat to Pittsburg. It is reported that $15,000 worth of oil was sold from these wells.

In the fall of 1860 (probably) a well was drilled on the Spears land about one mile south of Caldwell. At a depth of approximately 68 feet a strong flow of oil was secured. Adequate preparations for storing the liquid had not been made, so that much ran into the creek and was lost. It is estimated that this well produced 6,000 barrels. From that early time to the present, oil has been secured from the valley of Duck creek in the southern part of Noble county. By far the best part of the territory is that lying between Dexter City and Macksburg, but it forms the northern part of the Macksburg field and has already been considered.

Around Dudley, Olive township, nearly 40 wells have been sunk to the Berea since the fall of 1897. The excitement began when the John S. Dunn Company secured a 14 barrel producer on the land of Rebecca Tilton. The best well reported is Brown No. 2, drilled in 1898. It started at between 35 and 40 barrels, and flowed during a year or more, and now (September, 1900) is being pumped. On the average the wells start at 10 barrels per day. The number of producing oil wells in this pool in

1900 was 12. The oil, however, is not the most valuable product. There are 8 gas wells which have a high pressure and supply large quantities of fuel to surrounding towns.

According to Orton Dunn, the A. J. Ward gas well, completed April 13, 1899, had an initial rock pressure of 736 pounds per square inch, and an open pressure of 35 pounds through a 3-inch aperture. The top of the sand was found at a depth of 1,380 feet. After drilling 9 inches in the sand the pressure became so great that the drill could not be forced down further. The well was not shot. This supplies 200 families at Caldwell; 41 at South Olive; 120 at Dexter City; 40 at Elba, and about 25 farm houses along the line. Besides these it supplies 28 boilers for drilling and pumping. The Fulton Caldwell gas well No. 2, completed January 12, 1899, had an initial rock pressure of 730 pounds. On August 31, 1900, it had dropped to 385 pounds. Besides the John S. Dunn Company, the United States Company reaches this field and pipes the gas to Caldwell, Barnesvile, Quaker City, Cambridge, Byesville and Pleasant City. The Charter Oil Company, which formerly entered the territory, has sold its wells to the United Gas Company.

The gas rates in Caldwell are as follows (1900):

The United Gas Company makes a monthly rate of 50 cents per fire for a No. 5 mixer. For all illuminating purposes 15 cents per light is charged, but 50 per cent. of this is paid to the corporation for the privilege of entering the town. This charge is made to protect the Electric Light plant, owned and operated by the town. The John S. Dunn Company makes a rate of $12 per year for the first fire; $6 for the second; $2 for the third, and $1 for the fourth and each additional fire. These rates are for the No. 5 mixer. The company makes five-year contracts.

More recently a number of gas wells have been secured northeast of Dudley, and these supplement the supply received from the latter place.

At Moundsville in section 36 of Olive township, two Berea wells have been drilled. One of these was dry, but the other struck a large body of gas having a rock pressure of 650 pounds. Near Belle Valley some drilling has been done in recent years. Four producers have been secured, the first one in 1897. This started at 5 barrels per day, and still flows from 3 to 4 barrels. The remaining wells have a similar production, though two of them require pumping. The sand is the Berea, and lies 1,300 feet or more below the surface. It is very regular, the thickness ranging from 15 to 18 feet. Where oil is not found, salt-water is, and the latter is common in the thicker parts of the sand. The wells are cased through the Salt sand. An effort has been made to extend the producing territory both north and south, but as yet without success. Thus 6 dry holes have been drilled in sections 17, 18 and 19; while from 2 to 3 miles southeast from Belle Valley, failures are recorded in sections 33 and 34. In the extreme southeast corner of Jackson township a large number of

wells have been drilled to the 500-foot sand, but this territory forms a part of the Macksburg field, and has already been considered in that connection.

HARRISON COUNTY.

This county has been extensively tested for oil and gas, but doubtless much work remains to be done. The oil already secured has contributed directly and indirectly much to the wealth of the community, and it is not unreasonable to expect that this will be an important source of revenue to the county during a considerable period in the future.

The pools secured thus far (1903) are the following:

1. Cadiz;
2. Bricker;
3. Snyder;
3. Maxwell;
5. Jewett;
6. Scio;
7. Bowerstown;
8. Philadelphia Road;
9. Plumb Run.

Geographically considered they may be classed in two groups, the last five named making one, and the first four the other. In this discussion of the pools will be considered in this relation rather than in that of priority of discovery.

The surface strata in this county lie almost entirely in the Conemaugh or Lower Barren and the Monongahela or Upper Productive Coal Measures. Along the western side of the county the Upper Freeport or No. 7 coal, which lies just below the Lower Barren Measures, is found a short distance above drainage, while in the southeastern corner of the county, the Pittsburg or No. 8 coal, which makes the base of the Upper Productive Measure, is not far above drainage.

THE CADIZ POOL.

Discovery and Development.—In the summer of 1887 the Cadiz Oil and Gas Company drilled a well on the R. R. Cochran farm one mile north of the court house, the work having been done by Scott Watson of Braddock, Pa. His compensation was $1.25 per foot, but he was required to furnish casing, machinery, fuel, etc. When the Salt sand was reached a heavy flow of brine was liberated which ran from the top of the well, and the Berea sand, which was struck at a depth of 1,414 feet and was 50 feet thick, yielded neither oil nor gas. The company, however, was not demoralized by this failure, but in the fall of the same year began drilling a well on the farm of W. D. Rogers in the southwest quarter of section 29, of Cadiz township. This well was located not because of any indications of the presence of the desired products, but to hold certain leases on large tracts which the company had in that vicinity. Work continued until the Berea sand was struck, but the little gas found did not warrant piping the well, and accordingly it was abandoned.

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The second failure dampened the enthusiasm of the company but did not stop the work. However, at this stage counsel was sought, and had the information received been applied, the company would have secured two fine pools of oil which would have radically changed the profit and loss columns of the company's books. At the request of the company, the State Geologist, Dr. Edward Orton, visited the territory during the holiday vacation of 1887, and, from reports received from reliable citizens, ran several lines east and west from Cadiz to determine the arrangement of the strata, or in other words to locate, if present, anticlines and terraces, which he regarded essential to the production of oil or gas in large quantities. A preliminary survey was made with the aneroid barometer, and the principal variations in the dip noted, and then a surveyor was employed to run levels over the most promising territory. A report was made by the Geologist to the company early in January, 1888, but this seems to have been lost. Fortunately the citizens of Cadiz still remember distinctly the nature of the report, and besides the information secured in this manner the following paragraph taken from the Cadiz Republican, January 19, 1888, shows conclusively that Dr. Orton had determined the anticline of the region: "Professor Orton has furnished maps and drawings of this region of country to the Cadiz Gas and Oil Company, which show that the anticline of the region is to the east of the town. It is therefore well settled Geologically, that if either oil or gas is to be found here it must be found in that direction. The first two wells which the company have sunk were therefore in locations in which there was no hope of finding oil. The next well will be sunk in the right location from a Geological standpoint. Whether gas or oil will be struck there, of course, is an unsolved problem." The reports made by citizens of Cadiz are even more specific; they state that not only did he locate the anticline, but that he foretold the two places on it where conditions were most favorable. One of these is now occupied by the Bricker pool, and the other by the Snyder. In the former he stated correctly in what part oil and in what part gas would be found. In the latter pool, however, the tract which he regarded most favorable lies about a quarter of a mile east of the best wells. It is, however, within the producing territory. He advised against drilling west of Cadiz, but notwithstanding this numerous holes have been sunk, all of which have been failures.

A short time after the receipt of Dr. Orton's report the company began drilling another well, the location being on the Boggs heirs' farm in the southwest corner of section 29, Green township. This territory was within the area which Dr. Orton reported favorable, though he did not regard it as the most promising locality. The well made a good show of gas, the closed pressure being 150 pounds per square inch, but no oil. Salt-water was abundant, running from the top of the well. In June the company completed its fourth well, the Berea having been struck at about

1,400 feet. This was located on land of G. Fryer in the northeast quarter of section 34 of Cadiz township, and was within the territory reported favorable by the State Geologist. A small flow of oil and considerable gas were secured. The latter was allowed to escape for a year or more, and then the well was closed when the rock pressure rose to 250 pounds per square inch. The gas has been used for more than ten years, and in the fall of 1900 the production was 25,000 cubic feet per day.

On July 7, 1888, the company held a meeting to decide future action. Steps were taken to increase the capital stock from $10,000 to $30,000, but this seems never to have been accomplished. Four consecutive failures were too much for the organiation, and the company gave up the search, having gained considerable in experience if not in wealth. Why, it may be asked, did not the the company follow more closely the advice of the expert whose counsel it sought? The answer is simple, though ludicrous: The company did not hold leases on the territory which Dr. Orton regarded most promising for oil or gas, and though the land holders would have gladly granted the leases without expense to the company to have their farms tested, the company absolutely neglected to secure the leases, and so failed to test the territory where they were told their chances would be best. The discovery later of valuable pools of oil in the localities referred to is a fitting rebuke to the carelessness of the old company.

In the fall of 1888 a new organization, "The Berea Grit Oil and Gas Company" was formed. Its capital stock was $20,000, and its object was to test further the territory around Cadiz. Shortly after the company was organzed it began drilling on the farm of H. Morgan near the north line of section 33, Cadiz township. This is near the gas well drilled by the old company, and so is within the territory regarded as promising by Dr. Orton. A small show of oil was secured, but not enough to warrant pumping, unless other wells were secured. Within the following winter (1888-9) a well was drilled on land of E. G. Holliday, one-half mile east of the Morgan well. After having been shot with 30 quarts of nitro-glycerine the well made five barrels per day. In the summer of 1889 a well was drilled on the A. J. Petty farm, adjoining the Holliday on the east. This time a small production of both oil and gas were secured, and the well still (1901) yields each in about the same quantity as when first drilled. In the autumn of 1889 a well was drilled on the D. Norman farm which joins the Holliday. After having been shot with 60 quarts of nitro-glycerine the well produced 8 barrels of oil per day, and the lasting power of the sand was such that 12 years later it was yielding two barrels per day.

The poor success discouraged the company, and no further drilling was done for some time. The organization, however, still exists and has three producing wells in the pool. A half dozen or more wells have been

drilled since 1889, but nothing better than small producers have been secured. In 1901 there were 8 oil and 2 gas wells producing in the field. The pool has a length of less than one mile, and a maximum width equal to the length. The pool lies in the two townships, Cadiz and Green, including the southeast quarter of section 34 and the northeast quarter of 33 of Cadiz, and the southwest quarter of section 28 and the northwest quarter of section 27 of Green. The producing sand is the Berea, which may be regarded as in normal condition. The oil is found near the base of the formation.

One good act of the "Berea Grit Oil and Gas Company" was to secure the Fryer gas well, and pipe the fuel to Cadiz giving that place its first experience with natural gas. This was sold for fuel at 75 cents, and for light at one dollar per thousand feet. Since April, 1901, there have been rival companies supplying the town with gas. These are (1) The Cadiz Gas Company, and (2) T. N. Donaldson. The first company derives its gas from the Fryer wells, and supplied 300 families during the winter of 1900-1. The charge until April 1, 1901, was 75 cents per thousand feet, regardless of the use made of the gas, and since then the rate has been 25 cents per thousand feet. The second company derives its gas from the Jewett field, five miles north of Cadiz. In July, 1901, the company was supplying 50 families in Cadiz, its rate being the same as that of the other company.

THE BRICKER POOL.

This lies almost wholly in the eastern half of section 30 of Green township, and as developed in 1901 did not exceed one-half mile square in area. The pool is surrounded by dry holes, and so the productive territory cannot be greatly increased.

The oil was discovered in October, 1899, by the Bricker Oil Company, which drilled a well on the Bricker farm. The Berea sand was found charged with oil, the well flowing 125 barrels per day for a short time, making 13,040 barrels during the first 120 days. Other wells were begun at once, and drilling has been in progress ever since. The initial production has ranged from 8 to 125 barrels per day, several having started at the last mentioned figure. The compensation of the driller in this pool is 60 cents per foot, the operator furnishing everything[1] except fuel, or 70 cents when the driller furnishes boiler and engine. The wells are cased through the Salt sand.

The producing sand is the Berea. This is almost always found, but presents several interesting characters. The top of the formation is a fine grained sandstone which for some reason has been named a lime by the oil men. It has commonly a thickness of 18 feet, and really is the cap of the Berea. Below this in the Bricker pool is the pay-rock, having

[1]This does not include casing.

a thickness usually of 8 or 9 feet; this is succeeded below by a thick bed of sandy slate, and this in turn by about 10 feet of sandstone. A generalized section for the field is as follows:

	Feet.
Cap-rock, the "lime" of the driller	18
Pay-rock	8-9
Sandy slate	25
Sandstone	10

Other drillers, however, report the bed of sandy shale much thinner, and the stratum above correspondingly thicker. This results from the different ideas of what constitutes a sandy shale and a true sand rock, and in part from the varying thickness of the bed in question. The stratum is sometimes reported to disappear entirely.

The Pittsburg coal is found near the hill tops and the interval between this and the Berea sand is about 1,475 feet. The wells on the northwest side of the field produce much gas, while those on the southeast yield little, but contain much brine. A number of the wells flowed at first, but usually they had to be pumped after a few days. Well No. 1 on the Bricker farm flowed 9 months or longer. This well which was completed in October, 1899, had an initial production of 125 barrels; in July, 1901, it was pumping 20 barrels per day, thus indicating the lasting quality of the sand. The wells are shot usually with from 40 to 80 quarts, and some have already been shot the third time. The oil has a gravity of 46 degrees B., an amber color, and commercially is classed with the Pennsylvania product.

The pool lies on the eastern slope of a low anticline, and as has already been stated is one of the places where Dr. Orton reported conditions most favorable for oil production. The testing of the territory in 1899 appears, however, to have been independent of his report. The drillers do not discriminate between the Salt sand and the Big Injun. In fact the two are not sharply separated here as they are farther south, the "Big lime" not being recognized farther north than the extreme southern part of Belmont county.

THE SNYDER POOL.

This is located in the southern half of section 20 and the northeast quarter of section 19 of Green township, the productive belt, as developed in July, 1901, comprising less than one-half of a square mile. The number of producing wells at that time was 25.

The pool was discovered in the spring of 1900, the first well having been drilled on the William Croskey farm. A small well was secured, and is still being pumped. The next location was on the Snyder farm, immediately to the west, and a 25 barrel well was secured. Drilling has been in operation since that time and while the pool does not give promise of developing into a large one, it may be considerably extended on the west.

The producing sand here as elsewhere in the county is the Berea. The formation is similar to that in the Bricker pool, so what has been said concerning the sand of that place applies equally well here. The following skeleton record of Norman well No. 1 shows the relative positions of the principal formations:

	Feet.
Pittsburg coal at	12
Coal	592
Coal at	672
Coal at	825
Big Injun sand at	970
Bottom of sand at	1,050
Top of Berea ("lime" of the driller)	1,487
"Pay" in Berea	1,501
Bottom of well	1,512

The seam of coal lying about 580 feet below the Pittsburg is reported by the drillers everywhere in the Snyder and Bricker pools. The thickness assigned to it varies from 6 to 11 feet, but these figures must be taken with much allowance. Black shales, impure coals, and good coal are likely to be confused by the driller, and hence his figures are usually too high. It seems very probable, however, that a good seam of marketable coal lies at this horizon. This may contribute more to the future wealth and comfort of the county than the Pittsburg seam does at the present time.

The largest well secured thus far (July, 1901,) had an initial production of 30 barrels per day. The oil is similar to that of the Bricker pool, and hence commands the Pennsylvania price. The productive terriory forms a part of that reported favorable by Dr. Orton.

Outside of the pools alredy considered, a number of wells have been drilled to the Berea in Green township. On the Croskey farm near Unionvale in section 17 a well made a small showing of oil; on the Black farm near the center of section 18 a dry hole was drilled; on the Houser farm in the southeast quarter of section 14 a dry hole was drilled. This is about one mile east of the Snyder pool; on the Copeland farm near the middle of section 15 a dry hole was drilled; on the Howell farm in the southwest quarter of section 16 a dry hole was drilled; in the northeast quarter of section 21 three dry holes have been drilled on the Copeland farm, and a small oil well in the northwest quarter of the same section on the Hanna farm; also a dry hole in the southwest quarter of the same section on the Copeland tract; in the southern half of section 22 two dry holes have been drilled, one on the Croskey and the other on the Clifford land; a small showing of oil in a well on the McGavvan tract in the north half of section 26; a small well on the Hanna land in the northeast quarter of section 27. This list of failures does not include those which may be regarded as mark-

ing the limits of the productive pools. It may be well to remark here that the southeastern corner of the Jewett pool lies in section 28 of this township.

THE MAXWELL POOL.

This lies in Short Creek township, and is confined almost wholly to the southwest quarter of section 21. In July, 1901, the number of producing wells was less than a dozen, and from the dry holes which almost surround the pool, it appears that the productive belt cannot be materially extended. The pool was opened in the fall of 1899, the first well starting at 5 barrels. Work has been in progress since that time, and doubtless several wells will yet be drilled. The largest producer started at 20 barrels per day.

The oil is found in the Berea below the cap-rock, as is the case in the Bricker and Snyder pools. The oil has a gravity of 42½ degrees B., and a light amber color. Its characteristics are similar to those of the Cadiz pool, from which it is a half mile only distant. The gas present was sufficient to cause several of the wells to flow when first drilled, but all soon had to be pumped.

Other Wells in Short Creek Township.—Two dry holes have been drilled on the Giffin farm in the northeast quarter of section 26; a dry hole on the Yost farm in the southwest corner of section 5; a dry hole on the Shields farm in the northwest quarter of section 1; a well making much brine, but nothing else on the Hogan farm in the southeast corner of section 2; a dry hole on the Branson farm adjacent to the village Georgetown; a dry hole on the J. F. Hanna farm in the northwest quarter of section 13; a dry hole on the Stephens farm in the southeast corner of section 15; a dry hole on the J. N. Hanna farm in the southeast corner of section 24.

THE JEWETT POOL.

This is situated in the townships Archer, Green and Rumley. The principal part of the producing territory lies in section 34 and the southern half of section 35 of Archer township. Beyond this it extends into the southwest quarter of section 28 of Green and northward into section 35 of Rumley. The pool is well enclosed by dry holes on all sides except the south, and hence there is little prospect of extending the producing territory except in the one direction.

The pool was opened in the fall of 1895, the well having been drilled on land of A. M. Busby in the southern half of section 35 of Archer township. The well produced gas which was piped later to Jewett, and was not abandoned until the fall of 1899. A short time later another well was drilled on the same farm, and this also produced gas. Thus far the work had been done by the Jewett Oil and Gas Company, a local organization; but in the spring of 1896 this company transferred a large strip of territory

to the Ohio Oil Company, which drilled on the Busby farm and secured a 10-barrel well. From that time there has been slow but steady development. In July, 1901, the number of producers was approximately 75, of which 8 were gas wells. The companies operating in the territory at the date mentioned were the Ohio Oil Company, the Scott Oil Company and F. N. Donaldson.

The oil and gas are derived from the Berea sand, which has a thickness of about 40 feet. The pay-rock lies near the bottom of the formation and has a thickness of from 3 to 12 feet. The oil wells have commonly started at from 8 to 10 barrels, and so are regarded small, but the yield is maintained with persistence. The oil has a gravity of 45 degrees B. An important part of the field is the gas territory, of which there are two parts, one along the southeast border of the territory and the other along the northwest margin. The daily production of these had not been measured when the territory was visited, but the closed pressure on the northwest side of the field was reported at 450 pounds, and that on the southeast at from 250 o 300 pounds per square inch. The production of these wells is piped to Jewett, Cadiz and Scio.

The wells all produce some salt-water in the Berea, and usually much in the Salt sand and Big Injun. The casing extends through the latter formation. The strata in the principal part of the field dip to the northwest, and so lie on the western slope of an anticline. The Bricker and Snyder pools lie on the eastern slope of the same anticline. The gas wells on the northwest side of the field indicate that the rock is rising northwestward in that region.

THE SCIO POOL.

Location and Area.—The pool lies principally in North township, including in whole or in part sections 3, 9, 2, 33, 32, 1, 31, 26, 25, 30, 36 and 35; beyond this it extends east into Rumley, occupying parts of sections 13, 18, 19 and 24; at the extreme north the pool crosses into Carroll county, but this tract is so small that it is of very little importance. The producing territory extends northwest and southeast, and is triangular in shape, the base lying to the south. The maximum length of the field is about 5 miles, and the maximum width three miles.

Discovery and Development.—The search for oil in this locality began 30 years ago. As early as 1872 a number of derricks were standing along the edge of the village. One of these was on the Spiker farm, and was drilled by the old-fashioned spring pole method, an entire summer having been consumed in the work. These wells did not go beyond the Big Injun and so nothing but salt-water was secured. It is interesting to note that one of these wells was drilled by H. A. Snyder, who more than 25 years later organized the Scio Oil and Gas Company, which opened the pool. Equally interesting is it to report that the Spiker farm on which one of

these wells was drilled, became later one of the most valuable tracts in the field, more than $450,000 worth of oil having been secured from it. The early attempts failed simply because the drill did not go deep enough.

The discovery of oil near the neighboring town of Jewett in 1895, appears to have encouraged Snyder to renew the search in the vicinity of Scio. He accordingly began taking leases for oil purposes and secured options on about 2,000 acres near the village. His next step was to organize a company to test the territory, and in March, 1898, the Scio Oil and Gas Company was incorporated with a capital stock of $10,000, divided into shares of $25 each. The people, however, had little faith in the venture, and consequently the stock did not sell rapidly. Only 56 shares were disposed of, and even after the first well had been drilled and oil secured, there was difficulty in inducing the stockholders to double the amount already paid. This however, resulted more from their inability rather than from their lack of confidence in the project. After the second well had been completed the stockholders decided to double again their subscriptions, making necessary a payment of $100 for each share originally taken. The amount of money raised by the three assessments combined was $5,600. The company drilled two additional wells and put up rigs for two more, and then sold out to Myers and Brown for $100,000.

When the Scio Oil and Gas Company was organized, Snyder transferred to it his leases, the consideration being 4 per cent. of the oil secured and 2 per cent. of the gas, after the land holder had received his royalty. Much of the territory covered by these leases was dry, and other tracts were forfeited by the non-payment of rent. Nevertheless Snyder received a handsome fortune in return for his perseverence.

The first well drilled to the Berea sand in this pool was located on a small tract of land owned by Matthew Henry, situated one-fourth of a mile north of the village. The well was completed June 7, 1898, and after having been shot with 80 quarts of nitro-glycerine, began producing 18 barrels of oil per day. The second well, located on land of William Donaldson, started producing 22 barrels, but the necessary tanks not being at hand the well was left idle several days, the tools hanging in the well. When these were removed the well began flowing, and the gas catching fire from the boiler burned the derrick. This accident was widely published, and as is usual under such circumstances, the production of the well was exaggerated. The accident attracted the attention of oil men from near and far, and started a boom which in a short time revolutionized the village.

The third well was drilled late in the fall of 1898, on a lot owned by Jacob Strayer within the corporation limits. This began producing 75 barrels per day, and of course added fresh fuel to the excitement. After this wells were completed in rapid succession, and all were producers. Early in December the leasing of town lots began, and wells by the score

PLATE V

SCIO DURING THE BOOM

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were soon drilled on them, the owners vying with each other in their anxiety to have their property tested. Before tracing further the development of the territory let us consider the changes which the discovery of oil made in the village.

Before the discovery of oil Scio had a population of about 900, composed largely of retired farmers and others in well to do circumstances. It had long been a favored place for retired Methodist ministers who moved there because of the advantages which the college offered their children, as well as for the healthfulness of the location, the moral tone of the community, and the pleasant social conditions. The village had no manufactories, but derived its support from the students and the farmers of the surrounding country. Once only in 18 years was there a saloon in the town, and that one was soon driven out by the angry citizens. Billiard halls and bowling alleys were conspicuously absent, while card parties and dances were in bad repute. The discovery of oil worked the most sudden revolution ever seen in an Ohio town. The population of 900 in 1898 increased with amazing rapidity, and it is estimated by Prof. J. H. Beale, of Scio college, that in the following January and February it had risen to 12,000, though other well informed persons put the figure considerably lower.

The people came principally from the oil fields of Pennsylvania, West Virginia and Northwestern Ohio, and consisted of operators, drillers and teamsters; with them came those who supplied the necessities of life, boarding-house keepers, hotel men, butchers, etc. But with those necessary to develop the territory came a large number who maintained themselves by preying on the weaknesses of men,—the fakir, gambler, saloon keeper and dissolute woman were conspicuously present. There were 11 saloons in the town and an unknown number of "speak-easies." Three or four variety theaters were started, and the nights were made hideous by the barkers of all kinds. These features so horrified the staid citizens that they sold or rented their property and moved away. The village was unable to care properly for one-tenth of the people who had so suddenly gathered there. They lived in tents, shanties, reconstructed stables, boiler houses, or wherever they could find shelter. Many slept in chairs. Hundreds unable to find lodging left on evening trains for near by towns, returning the following morning. Finally the Pennsylvania railroad put on an extra train to accommodate the crowds. It ran between Pittsburg and Dennison, and was popularly known as the "greaser," because its patronage consisted largely of oil men. Rooms which previous to the excitement rented for 60 cents per week commanded from five to ten dollars for the same period.

The macadamized streets of the village were soon cut through by the heavy loads of oil supplies, and converted into mere mud canals, in many places so deep that the axles of an ordinary wagon would drag. It

was not uncommon to have horses mire in the deeper places, and have to be pulled out by another team.

The demand for men and teams was of course very heavy, and exorbitant rates were charged. Forty dollars a day were frequently paid, and one operator reported having given twenty dollars to have an ordinary boiler dragged 60 feet. The two railroads greatly increased their siding to accommodate the cars loaded with boilers, rig timbers, engines, machinery, etc. It was not uncommon to have supplies remain on the cars 10 days before they could be unloaded, so great was the rush.

As the number of wells increased the danger of fires became so great that nearly every policy in town was revoked, but later several companies took risks on what were regarded choice locations, charging as high as $100 per month, where from $5 to $6 per year had been charged before. Several large fires occurred and when the danger was at its height, a number of public-spirited citizens began the construction of a system of water works, which however, was not completed until the greatest danger was past. The cost of the plant was about $30,000.

It is hardly necessary to state that the general conditions then existing were very disastrous to the college. In 8 weeks time the attendance dropped from 300 to about 25, and all departments of the school except two were moved to New Philadelphia, 24 miles distant. After about 4 months, however, these were taken back to Scio.

The time of greatest excitement was during the first 3 or 4 months of 1899, when there were 75 strings of tools at work. After that a decline set in, and this was almost as rapid as the growth of the boom. The village, however, did not drop back to quite its former condition, the population in 1901 being between 1,200 and 1,300. An immense amount of money was left in the community, and the wells will be an important source of revenue for a number of years.

Of the early companies in the field, one of the most active was the Allegheny. After having drilled 26 wells in and around Scio, the company sold a part of its property to the United States Oil Company for $455,000, an exorbitant price, and later sold the remainder to the Consolidated Oil Company for an unknown sum. The most extensive operators in the field were the E. H. Jennings Brothers and Company, of Pittsburgh, who have had about 140 wells, nearly all of which are still producing (1901). While nearly all the land holders leased their property for a royalty of one-eighth the oil, occasionally a farmer operated his territory himself. This was true of the Hogue Brothers who drilled 47 wells on 160 acres, and all are still producing. The Pennsylvania and Wheeling and Lake Erie tracks run side by side through the south side of the field, and in the height of the excitement the right of way of these companies was leased and wells drilled on it about every 400 feet. The principal operators in the pool have been the following:

The Scio Oil & Gas Company.
Myers & Brown.
The Allegheny Oil Company.
Lecompt, Bruner & Company.
E. H. Jennings, Brothers & Company.
The Hogue Brothers.
Bailey & Robinson.
W. H. Milliken.
Conotton Valley Oil Company.
John Mildren.
C. R. Mildren & Company.
Jennings, Groves & Company.
Nassau Oil Company.
O'Day Brothers.
The Ohio Oil Company.
F. N. Donaldson.
Boyer & Caldwell.
Rhodes, Wilson & Reynolds.
Genesee Oil Company.

According to the guager for the Buckeye Pipe Line the largest number of producing wells in the field was in January, 1900, and numbered about 850. The total number of wells drilled in the field is about 1,000. Of these perhaps 220 were drilled within the corporation limits, but only about 20 of that number are still producing (1901). From a financial standpoint nearly all of the village wells were failures owing to their having been drilled so close together. A few, however, were very profitable: Thus one on the Given lot is reported to have produced $30,000 worth of oil. Three were drilled on the college campus, but the royalty derived was not large. The average cost of a complete well in the field was about $3,000.

The oil has been purchased and shipped by three companies,—The Buckeye Pipe Line, the Sun Oil Line and the National Pipe Line. The former was the first to enter the field, having begun pumping in December, 1898. It has shipped as high as 8,000 barrels in one day, but the average has been much less than this. In July, 1901, the average was about 1,100 barrels per day. The company has 3 tanks, each of 1,200 barrels capacity. From these the oil is shipped through two three inch lines, but about four miles east of Scio one of these changes to a four inch. These carry the oil to Brice, West Virginia, 42 miles distant. The second named company entered the field in the spring of 1899, and ships entirely by tank cars, not having a line leading from the field. At the height of the production the company shipped 1,500 barrels daily, but in 1901 this has decreased to 300 barrels. The oil is sent to Toledo where it is refined. The National Pipe Line Company, like the Sun, ships entirely by tank cars, the

oil going to Toledo, Findlay, Newberg and Cleveland. It entered the field in December, 1899, and began shipping the following month. The quantity shipped has ranged from 3,000 to 6,000 barrels per month. In 1899 a small refinery was built at Scio, and is reported to have used about 100 barrels per day. It was short lived, however, for in 1901 the Standard Oil Company secured control of it, and since then it has been quiet.

Geology of the Field.—The surface rocks lie in the Conemaugh formation or Lower Barren Coal Measures, the Upper Freeport coal passing below drainage a few miles to the west, while the Pittsburg coal appears in the hill tops a short distance beyond the eastern limit of the pool. Conotton Creek, flowing in a northwesterly direction and having a broad valley, divides the field into two nearly equal parts. Through this valley the two railroads run and the village is built on it. The topography of the field is rough. The succession of strata below drainage is shown by the following record:

Donaldson well No. 2. Data by J. R. Stevenson:

	Thickness of formation. Feet.	Total depth. Feet.
Conductor	40	40
Soapstone and slate	30	70
Limestone and slate	70	140
Cow Run sand	25	165
Slate and shells	20	185
Coal	5	190
Slate and shells	15	205
Coal	3	208
Slate and shells	27	235
Slate	10	245
"Hurry Up" sand	25	270
Slate	35	305
Coal	7	322
Slate and shells	73	385
Gas sand	50	435
Coal	2	437
Slate and shells	45	485
Sand	15	500
Slate and shells	55	555
Salt sand	45	600
Slate and shells	100	700
Big Injun sand	95	795
Slate and lime shells	362	1,157
Berea sand	33	1,190

The coal seam reported at a depth of 185 feet is probably the Upper Freeport. The sand rock lying 20 feet higher cannot be the Cow Run as named by the driller since the interval between the two should be about 100 feet. The Salt sand ranges in thickness from 40 to 75 feet, and usually contains a large quantity of brackish water, but is sometimes dry.

Below this formation is a bed of dark colored slate, having a thickness of from 15 to 25 feet, and this is succeeded in turn by the Big Injun, consisting of a series of alternating sand and slate layers, and having a thickness usually of less than 100 feet. At times it is charged with brine, but at other times is quite dry. The Berea has an average thickness of between 40 and 50 feet. The upper part of he formation changes gradually into shale, and so it is not sharply delineated. An average section of the formation in this field according to Prof. Beale is as follows:

	Feet.
Gray shelly sand	13-15
Like the above, but more compact and shelly	10
Pay-rock, fine even grained sand	6-11
Dark shale	1-20
Lower part of sand; called "Clover-leaf" by the drillers	3

The upper two divisions are known as "the lime" among the drillers. They are, however, a shelly sand rock containing some carbonate of lime. Thus far but little drilling has been done below the pay-rock, and hence the two lowest strata are not well known. It does not seem probable, however, that the "Clover leaf" sand extends over a considerable area. The most remarkable character of the sand is its absence of dry streaks. It is said that not a dry hole was drilled in the whole field. Of course in the village where a well was driven on nearly every lot, the sand was soon exhausted of oil, so that the later wells were unproductive.

The wells have not been large when compared with some found in other parts of the state. The best did not exceed 125 barrels per day. The production, however, keeps up well, and this, with the absence of dry holes, has made the field a very profitable one. The oil has a gravity of 42 degrees B., a red-brown color, and commands the Pennsylvania price. Usually the flow of gas from the wells has not been large, in fact the quantity has been scarcely sufficient for fuel to operate the wells, but on the west side of the extreme northern part of the field in sections 3 and 9, a few good gas wells have been secured. The rock pressure has reached 400 pounds, and in 1901 the fuel was supplying 175 families in Scio, the rate being 20 cents net per thousand cubic feet. These wells feed the boilers of the Buckeye Pipe Line, the rate being just half of the above. Salt-water has never been troublesome except on the extreme southern side of the field, where in some places the brine flows from the well.

The oil sand in the valley of Conofton creek dips very gently to the southeast. The much greater quantity of gas in the northern extremity of the field suggests that the dip there may be more pronounced, and the same may also be true of the southern margin which may explain the abundance of salt-water in that part of the territory. No evidence of an anticline was found, but the pool may lie on the eastern slope of a low arch.

Other Wells in North Township.—Outside of the Scio pool a number of wells have been drilled and additional tests were being made during the summer of 1901. One or more dry holes have been drilled in sections 27, 33, 15, 14, 8, 1, 13, 5 and 29.

THE PHILADELPHIA ROAD POOL.

This is a small area lying in the southeastern corner of section 13, and the southwestern of 7. The first well was drilled about 1899, but the quantity of oil secured was small and the well was abandoned. Other wells were drilled late in 1901 and with better results. Some work has been done from time to time since that date, with the result that a small pool has been secured. The wells are all small, and after having been pumped a short time do not produce more than from 2 to 10 barrels each per day. The oil is found in the Berea sand, and the rock is shot with from 60 to 100 quarts of nitro-gylcerine. The pool does not promise to become of any considerable importance.

THE PLUMB RUN POOL.

This occupies parts of sections 5, 6, 11 and 12 of Monroe township, and a small strip along the north line of Franklin township. The total area in February, 1903, was little in excess of one square mile.

The first well was drilled on the Isaac Miller farm in June, 1902, and began producing 10 barrels of oil per day. Work has been very active since that date, and the number of wells is now (April, 1903,) about 70. The principal farms are the McDevitt and Copeland. The wells are small. but dry holes are few and consequently the territory is quite profitable. The oil is obtained from the Berea sand.

THE BOWERSTON POOL.

This small pool lies in Monroe township, including parts of sections 1, 2, 3, 7, 8 and 9. It is circular in shape, and is almost surrounded by dry holes, and consequently does not promise to become much larger than it is at present.

The field was opened in the fall of 1899, the first well having been drilled on the Fisher farm. It yielded some gas. Another well was drilled the same fall. This was on the Heavlin farm, and it too produced gas. The first oil well was drilled in the spring of 1900, on the Amos Long farm, and started at 10 barrels per day. From that time until the present work has been in progress. The number of producing wells at present (July, 1901,) is about 125, of which 4 yield gas. The production of the pool at the date specified was about 600 barrels per day. In the fall of 1900 it was 950 barrels, the maximum of the field. The gravity of the oil is 42 degrees B. The Buckeye Pipe Line handles the product. The oil is collected by gravity into tanks, of which there are two, each of

1,200 barrels capacity, and is shipped to Brice, West Virginia, through a 3 inch line, the power being furnished by an engine of approximately 60 horse-power.

Like all other pools in the county the producing sand is the Berea. This has a thickness usually of 25 or more feet. The general relations of the sand are similar to those at Scio; at the top is the so-called "lime" having a thickness usually of from 6 to 10 feet; below this is the pay-rock having a thickness of from 6 to 14 feet. On the northwest side of the field gas is plentiful, but farther east and south the quantity is not sufficient to operate the wells. The highest pressure reported is 250 pounds per square inch. Salt-water is abundant on the southeast side of the field, it being estimated that at least 20 barrels are pumped to one of oil. The largest wells in the field started at 100 barrels per day, and those having an initial production of from 30 to 40 have not been uncommon.

The surface rocks lie principally in the Conemaugh formation or Lower Barren Measures, the Upper Freeport coal lying above drainage along the western margin of the field. The interval between this coal and the Berea sand is about 1,010 feet.

Other Wells in Monroe Township.—On the A. Wyant farm in the eastern half of section 33 a dry hole was drilled in 1894 to a depth of 3,950 feet. It was the intention to go to a depth of 4,400 feet, but the tools were lost and the well abandoned. The Berea was found at 1,085 feet. Three other dry holes have been drilled on the same section, one on the Grumble and two on the B. Wyant farms; a dry hole on the Brown farm near the south line of section 3; two dry holes on the northwest corner of section 9; two dry holes in the north half of section 26 on the Heller farm; a dry hole on the southeast corner of section 14; a dry hole on the Birney farm near the middle of section 31; three holes in section 1, one in the northeast quarter, one in the southeast quarter, both dry, and one making a showing of oil in the southwest quarter; on the southeast quarter of section 7 a well making a show of oil has been drilled on the Parker farm, and a second well was being drilled on the same farm in August, 1901; on the Long farm in the southeast quarter of section 13 a well making a showing of oil has been drilled, and another one was being drilled in the summer of 1901; on the Albaugh farm in the northeast quarter of section 30 a dry hole has been drilled; on the Betts farm in the southwest quarter of section 24, a dry hole has been drilled; on the Spray farm near the dividing line of sections 29 and 35 a dry hole has been drilled. It is understood that in all these wells except the first one, the objective sand was the Berea, and doubtless this was found in nearly every case.

OTHER DEEP WELLS IN THE COUNTY.

While depths cannot be given for the following wells, it may be taken with considerable certainty that they reached the Berea sand. The wells are enumerated here to show to what extent the county has been tested.

German Township.—A dry hole on the Lauther farm in the southwest corner of section 29; a dry hole on the Ralston farm in the southwest corner of section 18; a dry hole on the Johnson farm in the southeast corner of section 25; three dry holes near New Jefferson in section 26.

Rumley Township. — A number of dry holes have been drilled in this township just beyond the eastern margin of the Scio pool. These are located chiefly in sections 20, 13, 18 and 17. Besides these the following have been drilled: A dry hole in the southwest quarter of section 12; a dry hole on the Crabb farm near the south line of section 31; a dry hole on the Kimmell farm in the southeast quarter of section 7.

Stock Township.—A well making a showing of oil on the Henderson farm in the southwest corner of section 29; a dry hole on the McComis farm in the southeast quarter of section 34. This well is reported to have gone 700 feet below the Berea in search of the Gordon sand, but without success; a dry hole on the Lacey farm near the center of section 8; a dry hole on the Christy farm in the northwest quarter of section 14.

Franklin Township.—A dry hole on the Pittis farm in the northeast quarter of section 33; a dry hole in section 25 just south of the village Deersville.

Archer Township.—In June, 1901, a well was drilled on the Adams farm in the southwest corner of section 21. The Berea was found having a thickness of 45 feet, with from 7 to 8 feet of pay-rock at the bottom. The well began producing 10 barrels of oil per day. On July 23, 1901, a well was completed on the Welch farm adjoining the Adams, but the results were not as favorable as those in the Adams well. A dry hole was drilled on the Barger farm in the northeast quarter of section 20 in 1899, but a show only of oil was secured; a dry hole on the Strasbaugh farm in the northwest quarter of section 3; a dry hole on the Adams farm on the south side of section 15; a dry hole on the Hoover farm in the southeast corner of section 4; a dry hole on the Pittinger farm in the southwest corner of section 5; a dry hole on the Anderson farm in the southwest corner of section 23.

Cadiz Township.—A large number of failures are recorded in this township. Those outside of the Cadiz pool are the following: Two on the south half of section 33; one in the southwest corner of section 34; one near the middle and one in the northwest corner of section 35; one in the northwest corner of section 2; one in the southeast corner of section 6; one in the eastern part of section 10; one in the northeast corner of section 18; one near the center of section 22; one in the southwest corner of sec-

tion 26; two in the northwest corner of section 27; one in the southwest and one in the northwest corner of section 29; one near the middle of section 33.

Athens Township.—But three deep wells were reported in this township in 1901; in 1895-6 a well making a show of oil was drilled on the McFarland land in section 36; a dry hole was drilled later near the middle of section 11 on the Birney land, and one on the southwest corner of section 18 on the Johnson farm.

Moorefield Township.—Two deep wells, both of which were failures, are reported in this township, one on the Lantz farm in the southwest corner of section 24, and one on the Corban land in the northeast corner of section 34.

Nottingham Township.—Two deep wells, both failures, are reported in this township; one in the northeast quarter of section 6 on the Milliken farm, and one in the southeast corner of section 15 on the Cope tract.

Freeport Township.—Three tests have been made here, but all have been failures. One is in the southeast corner of section 10, another in section 18 near the village of Freeport, and the third in the southeast quarter of section 30.

Washington Township.—But two deep wells are reported in this township; a dry hole on the House estate in the southwest corner of section 10, and one on the Willison farm in the northwest quarter of section 21.

JEFFERSON COUNTY.

The search for oil and gas in this county has been persistent and extensive. The discovery of important reservoirs of natural gas in the adjacent part of Pennsylvania naturally stimulated the enterprising citizens of the Ohio Valley to test the rocks in their vicinity. Every township has had at least one deep well drilled in it, and in several they may be counted by the dozen. Several small reservoirs of oil and gas have been found, but the results have not been commensurate with the money expended. The surface formations lie almost if not entirely in the Conemaugh formation or Lower Barren and the Monongahela formation or the Upper Productive Coal Measures. The topography like that of the counties to the south and west, already discussed, is very rough. The productive sand is in all cases the Berea, which everywhere underlies the county, and which has been proven to be the lowest formation from which either oil or gas in commercial quantities can be expected. The principal pools or reservoirs are as follows:

1. The Gould Oil Field.
2. The Island Creek Oil Field.
3. The Toronto Gas Field.
4. The Port Homer Oil Field.
5. The Knoxville Oil and Gas Field.

THE GOULD OIL FIELD.

This comprises less than one square mile, and occupies part of sections 2, 3, 8 and 9 of Cross Creek township. It is situated three miles west of Mingo, and is traversed by the Pennsylvania railroad.

The pool was discovered in 1895, the first well having started at 125 barrels per day, but the decline of this was so rapid that the well was abandoned in one year. The second well, which was drilled a short time afterwards, started at only 10 barrels per day, but was still producing in 1901. Work was pushed with energy and by 1898 the drilling had been done. It is stated that no wells have been drilled in the field since that time. Of the 60 wells drilled, at least 25 had been abandoned by August, 1901.

On the extreme western edge of the pool several gas wells have been secured, and the product of these was used to operate the territory. Generally the gas produced by the oil wells was small, so that the greater number had to be pumped from the start. It is claimed that at one time the field produced 1,200 barrels per day, but by the summer of 1901 this had dropped to 200 barrels or less per week. The oil has a bright red color and commands the Pennsylvania price. Salt-water is abundant, but is much less so on the northwest side of the field than it is on the southeast. The wells were shot at first with from 30 to 200 quarts of nitroglycerine, and many have been shot a second time, this charge being as a rule smaller than the first one. The Berea is found in the valley at about 1,200 feet, and has an average thickness of perhaps 33 feet. From what has been said of the number of abandoned wells, it is clear that the sand is quickly exhausted, and the field must necessarily soon become a thing of the past.

As might be expected a number of wells have been drilled along the eastern edge of this township in the valley of the Ohio river. Four or five have been sunk within the city limits of Steubenville alone, but the results have fallen far short of the expectations of the operators. Three of the wells produced gas, but in small quantity, and all but one have been abandoned; the latter well supplies gas for one family only. These wells reached the Berea at about 1,250 feet, but the sand was thin and unimportant.[1] Two wells, both dry, have been drilled in or near the limits of Mingo. In the southeastern corner of the township in section 25, a dry hole has been drilled. Southwest of the Gould field a number of wells have been sunk in sections 7, 13, 14 and 19. These have been failures, but have made sufficient showing of oil to induce further exploration.

THE ISLAND CREEK FIELD.

This lies in sections 5, 11, 16, 17 and 22 of Island Creek township, has a length of about 3 miles and a maximum width of less than one-quarter of a mile.

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 336.

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The pool was opened in the fall of 1889, the first well having been drilled on the farm of James Blackburn. The Berea was found at a depth approximating 1,000 feet, and a 30-barrel well was secured. This is still producing, but not more than one barrel per day. Drilling has been in progress irregularly since that time, and by August, 1901, forty-five wells, of which seven only were dry, had been completed. The wells were small, the greater number starting at from 8 to 10 barrels. The pressure of gas has been light, so that many wells have had to be pumped from the start. Considerable salt-water is found, but the field is quite spotted in this respect.

The following record of McKeown well No. 2, on the Morrow farm, shows the stratigraphical succession:

	Thickness of formation. Feet.	Total depth. Feet.
Conductor	20	20
Slate	20	40
Limestone and shells	20	60
Sand	14	74
Slate	101	175
Sand	25	200
Slate	150	350
Sand	40	390
Slate	180	570
Sand	70	640
Slate	95	735
Sand	132	867
Slate	295	1,162
Shelly slate	10	1,172
Black slate	40	1,212
Berea sand	29	1,241

The sand struck at 570 feet is the Salt sand, and that passed through at 867 marks the base of the Big Injun. While the wells in the pool have all been small they are nevertheless valuable, since they are long-lived. As late as August 1, 1901, two wells only had been abandoned.

THE TORONTO GAS FIELD.

This lies near the village of Toronto, in the northeast corner of Island Creek township, and is restricted almost wholly to section 36.

The wells, 12 in number, are reported to have been drilled in the years 1891-2. Of these 3 were failures, and of the others 6 were still producing in 1901. The closed pressure was originally 325 pounds per square inch. A feature of the field is the absence of salt-water, the wells not requiring packing. Originally the wells were owned by the Toronto Oil and Gas Company, but they have passed into the control of the Tri-State Oil and Gas Company. The gas is piped to Toronto, where a rate of 22½ cents net per thousand cubic feet is charged.

Outside of the two fields mentioned a number of wells have been drilled in this township: One dry hole on the Robertson farm in the eastern half of section 7; a dry hole on the Dobbs farm in the southwestern quarter of section 33; a dry hole on the Walker farm near the west line of section 10; a dry hole on the Finley farm in the northwest quarter of section 34, and one on the Powell farm in the northeast quarter of the same section; in the northeast quarter of section 5 three wells, two of which were dry and the third a small producer, now abandoned; two dry holes in the southwest corner of section 12. It is safe to say that all these wells extended to the Berea sand.

THE PORT HOMER OIL FIELD.

This is a very small pool occupying parts of sections 5 and 6 of Saline township. The first well was drilled in the winter of 1899-1900, but was very small, making a barrel or two only per day. The Berea grit is said to have been struck at a depth of 715 feet. In the spring of 1900 the second well was completed and started at 100 barrels per day, but this rate was not long maintained. Work has been progressing since that time and about 20 wells have been drilled, but more than one-third of these were dry. The Berea is found along the river front at depths ranging from 600 to 620 feet, but on the opposite side of the river the same formation is reported at 598 feet. However, the surface there is lower. The relations, nevertheless, strongly suggest a low arch with the Port Homer wells on the western slope.

A number of deep wells have been drilled in other parts of the township: Two dry holes near the river in the extreme southeastern part of the township; a dry hole in the southeast corner of section 5; a dry hole on the McCullough farm near the west line of section 7; a dry hole near the mouth of Yellow Creek in section 8; two dry holes, one on the Mills and the other on the Gray farm, in the southwest corner of section 11; three wells on the Taylor farm in the southeast quarter of section 17, two of which produced some oil, while the third was dry; a dry hole on the Burnett estate near the south line of section 18; a small producer, now abandoned, on Yellow Creek along the eastern line of section 13, and a dry hole near the middle of the same section; two small oil wells and one dry hole on the Leatherberry farm in section 23; a dry hole in the village of Irondale. In all these wells the objective plane is the Berea grit, and it is not improbable that every well reached that horizon.

THE KNOXVILLE OIL AND GAS FIELD.

This is a small area lying on the east and west sides of the village of Knoxville, in Knox township. The producing territory lies in sections 14, 15, 20 and 21, but does not embrace over one-half of a square mile. The first well, which was drilled in 1896, started at two barrels only per

day, but the next well began producing 27 barrels, and is the largest producer in the field. Nearly all of the 17 oil wells were drilled in 1896. They lie west of the village, while the gas wells lie to the east. The gas wells, four in number, were drilled within the past two years. Their closed pressure is reported at 325 pounds per square inch. They are owned by the Tri-State Gas and Oil Company, but have not been used as yet. Mr. J. J. Crawford, who is well informed concerning the field, reports that the oil wells lie on the western slope of an anticline and the gas wells on the summit. Both products are derived from the Berea grit, which has a thickness of about 50 feet, and is quite constant in character. The sand is fairly dry, and but little water is found in the Salt sand.

A large number of wells has been drilled in other parts of the township: A dry hole on the river bank in the northeast corner of the township; three small gas wells in or near the village of Empire; a dry hole on the Sapp farm in the southwest corner of section 33; a small gas well on the river bank near Calumet P. O.; a dry hole in the village of Toronto; a small gas well on the Gaston farm in the southeast corner of section 31; a dry hole on the Wasson farm in the southwest corner of section 1; a dry hole on the Snyder farm in the southeast corner of section 2; a dry hole on the Fitzpatrick farm in the northeast corner of section 3; two dry holes on the Taggart farm in the northeast corner of section 4; two dry holes on the western half of section 10, one on the McGhie, and the other on the Runyon farm; two oil wells and three dry holes in the northeast corner of section 16; a dry hole on the Cooper farm in the northeast corner of section 15; 2 dry holes on the southern half of section 14, one on the Mills and the other on the Andrews farm; one oil well and 3 dry holes in the northwest quarter of section 13; a dry hole on the Swickard farm in the southwest corner of section 20; 4 small oil wells and 2 dry holes in the eastern half of section 26. It may be taken with almost certainty that these wells reached the Berea grit.

OTHER DEEP WELLS IN JEFFERSON COUNTY.

Brush Creek Township.—A well was drilled on the Hickman farm in the northeast quarter of section 2 in the fall of 1900, but was dry. In the summer of 1900 a deep well was drilled on the McBane farm in the southeast quarter of section 15. It made a show of gas, but no oil. Several years ago a Berea well, which was dry, was drilled on the Dorrance farm in the southeast quarter of section 32. More recently a small oil well was drilled on the Moore farm in the southwest quarter of section 31.

Ross Township.—A number of deep wells have been drilled in this township, some of them, according to report, many years ago. It is not improbable that the earliest of these went no deeper than the Salt sand. On the E. George farm in the southwest corner of section 23 three wells have been sunk; of these two were dry, but the third yielded some oil, though

it is now abandoned. On the A. George farm in the northeast quarter of section 28 the same number of wells has been drilled with results similar to those previously reported. Two dry holes have been drilled on the McLain farm in the northern part of section 6. All the wells reported are along Yellow creek. In early times the brine from the wells was used for the manufacture of salt. It is said that oil in commercial quantities was not found in the Berea, but that it was occasionally found in the Big Injun. A small quantity of oil is reported to have been hauled away from this valley between 1860 and 1870.

Springfield Township.—A dry hole was drilled on the Dorrance farm in section 4 near the village of Bergholz, and one on the Calhoun farm in the southeast quarter of section 8.

Salem Township.—A dry hole has been drilled on the Graham farm in the southwest quarter of section 23, and one on the Kirk farm in the northeast quarter of section 22.

Wayne Township.—A Berea well was drilled on the Reed farm in the northwest quarter of section 23 in 1899. The sand was found at a depth of 1,200 feet, and has a thickness of 41 feet. The well made a show of oil and considerable gas. Another Berea well was drilled on the Blackburn farm in the same section. It made nothing better than a show of oil. Other dry holes have been drilled as follows: One on the Hervey farm in the northwest quarter of section 28; one on the O'Brien farm in the southeast quarter of section 24; one on the Starr farm in the northwest quarter of section 18; two in section 17, one each on the Maxwell farm in the northwest quarter, and the Simeral farm in the southeast quarter; one on the Miser farm in the southwest quarter of section 12.

Smithfield Township.—Two Berea wells, both dry, have been drilled on the J. M. Galbraith farm in section 11. The first one was drilled about 1895 and made a show of oil. Its depth was approximately 1,560 feet. The second well was drilled in 1900 and had a depth of over 1,600 feet. In section 10 four wells have been drilled, all in 1900, and the fifth well was being drilled in the summer of 1901. One of these wells produced 25 barrels of oil per day when first drilled, and in July, 1901, was producing between 6 and 10 barrels in the same length of time. The other wells were dry. On the Runyon farm in section 17 a Berea well was drilled in 1896.

The log of this well is as follows:

	Thickness of formation. Feet.	Total depth. Feet.
Conductor	15	15
Coal (Pittsburg)	6	21
Shale	19	40
Buff colored rock	80	120
White shale	160	280
Black sand	25	305

	Thickness of formation. Feet.	Total depth. Feet.
White shale	10	315
"Hurry-up" sand	60	375
Black shale	10	385
Bastard limestone	10	395
First Cow Run sand	50	445
White shale	60	505
Second Cow Run sand	25	530
White shale	65	595
Black shale	50	645
Coal	9	654
Black shale	20	674
First salt sand	80	754
Black shale	110	864
Second salt sand	55	919
Big Injun sand	250	1,169
Slate	25	1,194
"Squaw" sand	20	1,214
Slate and shale	358	1,572
Berea sand	35	1,607

It is seen from this record that the interval between the Pittsburg coal and the Berea grit is 1,551 feet. The Cow Run sands, so-called, are out of place. Instead of an interval of 400 feet between the two, the interval here given is only 60 feet. As has already been stated in this report, no reliance can be placed on the drillers identification of this sand. The great thickness of the coal seam found at 645 feet should be taken with much allowance.

On the Kithcart farm in section 15 a dry Berea well was drilled in 1896; a dry well has been drilled near Adena in section 32; on the Sutherland farm in section 28 two wells, both dry, have been drilled; two wells, both dry, have been drilled in section 29, one on the Thompson and the other on the Henry farm; on the J. B. Smith farm in section 30 a dry hole was drilled several years ago; on the Wm. B. Scott farm in section 5 the Berea was found at about 1,700 feet, but was dry; in section 6 two Berea wells have been drilled, one on the Sutherland and the other on the Cope farm, and both were dry; near the eastern margin of section 14 two dry holes have been drilled, and one near the western margin of section 8. It is thus seen that of the 20 Berea wells drilled in this township, one only is a producer.

Mt. Pleasant Township.—Three dry holes have been drilled in this township, one in the southwest quarter of section 4, one in the northeast quarter of section 18, and one in the northwest quarter of section 29.

Wells Township.—Several Berea wells have been drilled in this township: A dry hole on land belonging to the bank of Smithfield in the southeast quarter of section 21; a dry hole in the northeast quarter of section 28; a dry hole on the Puntney farm in the southwest quarter of section 18;

a dry hole in the southwest quarter of section 35; a dry hole on the Hundman farm in the northeast quarter of section 12; a dry hole on the Ekey farm in the southeast quarter of section 11. Several wells have been drilled at Brilliant on the river bank. One of these produced gas, which was used in a rolling mill. The well is said to have been ruined by the flood of 1884. The interval between the Pittsburg coal and the Berea sand in this locality is reported at 1,560 feet.

Warren Township.—One dry hole has been reported from this township. This was drilled many years ago near the village of Portland.

COLUMBIANA COUNTY.

The surface rocks in this county lie in the Allegheny formation or Lower Productive and the Conemaugh formation or Lower Barren Coal Measures. The eastern and southern parts are hilly, the highest points rising more than 500 feet above the valley of the Ohio river. The strata dip rapidly to the south: thus at Wellsville the Berea is found at a depth approximating 550 feet below the river valley, while at Steubenville the same formation is found at about 1,200 feet. The distance between the two places is about 20 miles. From this county north the Berea ceases to be a deep formation, meaning by this that the sand rarely attains a depth of 800 feet, even in the south, and in many cases is much less than this.

A very large amount of drilling has been done in this county and much of it dates back to an early day. The city of East Liverpool, in the southeast corner of the county, must be regarded as one of the pioneer natural gas places in this country. The first well is reported to have been drilled in 1859,[1] and to have found gas at a depth of 450 feet. Whether this well resulted from Drake's discovery in Pennsylvania, or whether from a search for brine for the salt works, does not appear certain. It is claimed that after this well was finished a committee went to Fredonia, New York, to ascertain what use was there made of the gas and how it was controlled.

Mr. H. R. Hill reports having found a deep well drilled at this place on his return from the army in 1865. It was sunk for oil, but was unsuccessful in this respect. However, it did yield gas, though this was regarded worthless. Mr. Hill secured control of this product, and used it in two residences and a pottery. Later he drilled another well near this one, securing so strong a flow of gas that the well was known as the "Bonanza." Among other purposes this gas was used for lighting the streets. Several additional wells were drilled in the same vicinity, and then Mr. Hill sold out to the Bridgewater Gas Company. From the period of these early wells drilling has been done from time to time in this vicinity until 1900, when two wells were sunk in the Ohio valley. The prime object of nearly all this work was to secure gas for the potteries, but the effort has been unsuccessful. The production has been small and the

[1] *Encyclopedia Brit.*, Ninth Ed., Vol. X, p. 88.

wells short-lived. According to Dr. Orton, gas was first used for lighting the streets and for domestic purposes in a general way in 1874. The number of families supplied at that time was between 50 and 60, the charge being from $2.00 to $2.50 per month for each fire.

The gas is derived from the Berea sand, which has a thickness ranging from 60 to 120 feet. It is worthy of note that as this formation rises nearer the surface its thickness increases. Concerning the structure of the field Dr. Orton says:[1]

"East Liverpool lies in whole or in part, upon a low fold in the strata which is probably an extension of the Fredericktown anticlinal of Prof. I. C. White. The reality of the fold is made apparent from the fact that the Berea grit descends in both directions from Liverpool. At Dry run, four miles east, it lies about 100 feet lower than it does at Liverpool. At Wellsville, four miles west, it lies seventy feet below the Liverpool level, as has been demonstrated by the drilling of a number of wells at this point."

In the search for oil and gas, work has not stopped with the Berea. In the Knowles well a depth of about 2,500 feet below this was reached. Beneath the Berea two sand formations were found, one at a depth of 964 and having a thickness of 41 feet, and the other at 1,800 and having a thickness of 5 feet. The higher of these two sands is reported to resemble closely the Berea, and also to produce gas. The lower of the two contained a small quantity of both oil and gas. The result of this well, however, was far from satisfactory, and it came to be recognized that when the Berea sand was passed and was found dry that the last hope of gas or oil was gone. It is worthy of note that this deep well did not reach the base of the Ohio shale formation.

Yellow Creek Township.—A well is reported to have been drilled in the valley of Yellow creek in 1865, and to have begun producing 100 barrels of oil per day, the pay-rock having been struck at a depth of 540 feet. Two additional wells are said to have been drilled about the same time in that vicinity, but the results must have been unsatisfactory, for with them work ceased for nearly 25 years. Late in the eighties a Wellsville company interested in the iron business drilled a well to the depth of 3,250 feet on the Hibbits farm in search for gas for its mills. A small flow was secured in the Berea, but the great shale series below was barren, so that the well was a failure. In 1899 the Wellsville oil field was discovered, the first producer having been drilled on the James Wells farm, just north of the town. The well started at 15 barrels per day, and drilling has been done at irregular periods from that day to the present time. Nearly 20 oil wells have been secured. These have, in the main, been drilled close together, and so occupy a very small area. The wells have started as high as 200 barrels per day, but the decline has been rapid. In August, 1901, the pool

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 335.

was producing about 500 barrels of oil per month. About one mile northeast of this field several gas wells have recently been drilled on the Bane, Adams and Stroup farms. In the summer of 1901 no use had been made of them, but it was the intention at that time to pipe their production to Wellsville. The rock pressure of these wells was reported at 350 pounds. The oil and gas in the Wellsville field are derived from the Berea grit, which is uniform in character and has a thickness of about 45 feet. This formation is quite dry, but there is considerable brine in the Salt sand.

Deep wells have been drilled in other parts of the township as follows: A small well on the Johnson farm two miles north of Wellsville; a dry hole on the Kerr farm one-half mile west of the Johnson well; a dry hole on the A. R. Smith farm near the middle of the north side of the township; a dry hole on the Wm. McBane farm in the northwest corner of the township; a small well on McQueens run near the lower end of Wellsville; a dry hole on the Boyd farm near the middle of the township; a dry hole on the Runyan farm near the southeast corner of the township; a dry hole on the Hammond farm about one mile west of Wellsville; a dry hole on the James McBane farm in the southwest quarter of the township.

Madison Township.—At and in the vicinity of Williamsport in this township and in corners of the adjacent townships of St. Clair and Elk Run a number of deep wells have been drilled within the last 40 years. For information concerning this territory the Survey is indebted to Mr. W. H. Crawford, who has been in the field during the long period mentioned. In 1860 or 1861 Mathers and Hanna, of New Lisbon, drilled a well on the W. H. Crawford farm, striking the Berea sand at 550 feet. This yielded a little gas but no oil. It is claimed that this well was begun with the old-fashioned spring-pole, that the middle portion was drilled with horse-power, and that it was finished with steam. At or about the same time that this well was being drilled another one was being sunk by water power on what is at present known as the Cliff farm. A little later a well, located by a "smeller," was drilled on the same tract and gas pressure sufficient to blow the tools from the well was secured. The people, however, were afraid of the well, and hence it was abandoned. The next well was located by an oil "smeller," the Rev. Patterson, of Darlington, Pennsylvania, on the Conkle farm in the northwest corner of St. Clair township. The Berea sand, having a thickness of 70 feet, produced a heavy oil suitable for lubricating purposes, and it is said that over 1,000 barrels were hauled away. In 1865 a well was drilled on the James Crawford farm, in Elk Run township, and a strong flow of gas was found in the Berea. This, however, was regarded as worthless and the well was abandoned. The same year a well was begun on the Russell farm, in Madison township, but at a depth of 420 feet was abandoned. The driller declared that there was no use going deeper when the sand was too fine to contain water.

From that time until 1887 the field was quiet. In the latter year three wells were drilled in the vicinity of Williamsport. One of these was located on the W. H. Crawford farm in the northwest corner of St. Clair township. In this the Berea was found at a depth of 650 feet and produced a small quantity of gas. Work continued until a depth of 1,600 was attained, but neither oil nor gas was secured. The second well, drilled on the Alum Cliff farm, attained a depth of 930 feet, and made a little oil and considerable gas. The latter supplied two residences during the ensuing 12 years. The third well was drilled on land of James Robinson, in Madison township, and the Berea yielding nothing more than a small quantity of gas, the drill was kept at work until a depth approximating 3,000 feet was reached. About 250 feet below the Berea a stratum of soft sandstone three and one-half feet in thickness was found, but it yielded nothing, and the well was of no service beyond showing that when once the Berea sand has been passed all hope of securing oil or gas must be abandoned in this part of the state.

No further work was done in the territory until 1897, when a well was drilled on the old Conkle farm, now owned by John Davis. It made a show only of oil. A well was drilled in the same year on the Alum Cliff farm, the result being a gas pressure of 170 pounds per square inch. Later it began yielding a small flow of oil and in 1901 was still producing. Other wells were drilled in the same territory that year and further testing has been done from time to time until the fall of 1900. During the three years preceding the latter date 22 wells had been drilled in the field. In August, 1901, there were 5 producing oil wells, the largest making 3 barrels only per day. The oil has a gravity of 33 deg. B., and is used as a lubricator. When the gas production was at its height the Alum Cliff Gas Company piped the product to East Liverpool. The output of the wells, however, speedily declined, and in 1900 the line was removed. In the summer of 1901 the wells supplied 11 families, but the yield more than met this demand.

The Berea sand has a thickness of 70 feet in this territory. The gas is usually found at a depth of about 50 feet and the oil near the base of the formation. The sand is fine and hard except where the oil is present. But little salt-water is found in it.

Outside of this field a number of deep wells have been drilled in Madison township: On the J. Crawford farm in the southeast corner of section 11 two Berea wells have been drilled; of these one was dry and the other made a little oil; on the neighboring farm owned by S. McGurdy a well was drilled within the past two years; a well is reported to have been drilled at the village of West Point many years ago, and to have produced a small amount of heavy oil which the farmers used as a lubricator; a few years ago a well was drilled on the farm of J. McCready in section 32, but made nothing more than a small showing of gas.

St. Clair Township.—Beside the wells already mentioned as forming part of the Williamsport field the following have been drilled in the township: On the Moore farm in the northwest quarter of section 17 a Berea well producing some gas, about the year 1900; on the Rayl farm in the northeast quarter of section 19 a Berea well having a closed gas pressure of 125 pounds per square inch; a Berea well yielding some gas on the McDonald farm in the northwest quarter of section 30; a well making some gas on the T. W. Huston farm in the southwest corner of section 21; a number of producing wells along the Middle Fork of Beaver creek in the eastern part of the township from Fredericktown south. Drilling is said to have been begun in the latter locality many years ago. The production is derived from the Berea sand.

Elk Run Township.—A well is reported to have been drilled on the Cope farm in the southeast quarter of section 24, before the civil war. Formerly it yielded much gas and is said to be used in the farm residence at the present time. Many years ago a well making considerable gas was drilled on the Thompson farm, near Elkton. This encouraged further exploration and three wells have since been drilled, all of which were failures. About the year 1898 a Berea well was drilled on the Wilson farm in the southeast quarter of section 25. The sand was reported nearly 100 feet thick, and so charged with salt-water that the latter rose rapidly to the top of the well.

Center Township.—Wells have been drilled in the vicinity of Lisbon at various periods during the past 40 years. The earliest of these were in search of oil, and were put down not many years after Drake's discovery in Pennsylvania. All were financial failures. They disclosed, however, large quantities of salt-water and some gas, and resulted in the establishment of salt works, the gas having been used as fuel. These works have long been abandoned. The modern work in the search for oil and gas in this vicinity began about 1884, when a well was drilled just south of Lisbon to a depth approximating 1,600 feet. The well yielded a small quantity of both oil and gas, but not enough of either to warrant operating, and so was abandoned. In 1886 a well was drilled on the Valker tract along the Lisbon corporation line. Work did not cease until the drill had passed 972 feet below the Berea.[1] A sand rock having a thickness of 12 feet is reported to have been found 450 feet below the Berea, though it is not given in the record to which reference has just been made. The Berea yielded some gas, which was used in the city mains, but salt-water soon ruined the well. Three additional wells were soon drilled in the same vicinity, one reaching a depth of 1,100 feet, but the remaining two stopped with the Berea. Of these one was dry but the others yielded some gas, one of which is still producing. About the same time a well was drilled at the United States Tile Works. It made some gas but was soon ruined

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 322.

by salt-water. Three additional wells were drilled in the vicinity of Lisbon late in the eighties, but without satisfactory results.

No further exploration was done in this part of the county until 1899, when two Berea wells were drilled within the Lisbon corporation. Both were failures. In the same year a Berea well was drilled on the Harbaugh farm, one-half mile southwest of town, but this well also was a failure. About the same time a well was drilled one mile southwest of Lisbon on the old Philpot farm. A shallow sand, found at a depth of about 375 feet, made a good show of gas, and the Berea yielded gas, oil and brine, but the well was abandoned. In the winter of 1900-01 work was begun on the Fink farm along the line separating sections 32 and 33, and since that period three additional wells have been drilled. All reached the Berea, and 3 produce gas, the rock pressure of which was between 250 and 300 pounds per square inch. No use was being made of this as late as August, 1901, but the owners of the wells expected to pipe the production to Lisbon. The Berea grit in the vicinity of Lisbon has an average thickness approximating 50 feet. The sand contains much salt-water, thus greatly damaging the territory.

Unity Township.—A deep well is reported to have been drilled on the old Mendenhall farm, about one mile east of New Waterford, somewhere between 1860-70. It is reported to have yielded a small quantity of heavy oil and much salt-water, the latter supplying the salt works for a short time. The well has long been abandoned. About the year 1889 a well having a depth approximating 800 feet was drilled in the village of New Waterford, and after having been shot produced a small quantity of oil. It was pumped a short time and then abandoned. This well encouraged further explorations, and one located on the Thompson farm one-fourth of a mile east of the village was soon begun. At about 600 feet some gas was found, and at 1,200 feet a show of oil. Work did not cease until a depth of 1,700 feet was reached, but nothing was found to repay the operator for his heavy expense. No further work was done until 1897, when a well was drilled on the land of Ephraim Ruperts, adjoining the Thompson farm. A good show of gas was found in the Berea at a depth between 600 and 700 feet, but a heavy flow of brine was encountered below the pay-rock, and this ruined the well. Another one was then drilled on the Thompson place and the gas secured in the Berea was piped to New Waterford, but brine soon overcame the gas. Eight additional wells have since been drilled near the village, the last one in 1899. Nearly all made some gas, and the results simply duplicate those already given. They supply the village with light and fuel, the rate being 25 cents per thousand cubic feet, with 2 per cent. off for cash. Salt-water is the great enemy of the field. It lies below the pay-rock, from which it is separated by a hard stratum. When the latter is penetrated the brine rises and drowns the gas. The productive strip has a length of one mile and a width of perhaps one-eighth of a mile.

On the Flowers farm, near East Palestine, along the east side of the township, a well was drilled about 1890, and is reported to have gone to a depth of between 1,700 and 1,800 feet. No data as to the results are at hand, but it is safe to say that the well was a failure.

Middleton Township.—About 1899, a Berea well which was a failure was drilled on the Huston farm in section 34. In 1900 a well was drilled near the village of Mill Rock. The depth has not been learned, but it probably extended to the Berea sand. It made some gas, but the quantity was small, and the well was abandoned.

Fairfield Township.—Two wells were drilled on the Nichols farm, about two miles southwest of Columbiana, in 1900. The Berea was found in normal position and character, but was dry in one well, and made a show only of oil and gas in the other.

Wayne Township.—A well has been drilled on the Rice farm in section 15. No definite data are at hand, but it is known that the well was a failure. There is no reason to doubt that the Berea grit was found.

Knox Township.—Two small pools have been discovered near the village of Homeworth, in this township. One lying northeast of the village was discovered in 1899, the first well having been drilled on the Yaggi farm. The Berea sand was reported at a depth of 618 feet, and was 35 feet thick. The production of oil was small, but the well is still (1901) being pumped. In the same summer a well was drilled on the Cameron farm, one mile southwest of the Yaggi tract, and began producing about 7 barrels per day, a rate that was being maintained in August, 1901. Drilling has been done in the field off and on from the time of the completion of the first producer, and about 30 wells have been sunk, of which one-third were dry. The best wells had an initial production of about 15 barrels per day, but the rate soon decreased to a small fraction of this. The sand contains but little gas, and consequently the wells have to be pumped from the start. The oil commands the Pennsylvania price, and is shipped in tank cars. The Berea sand ranges in thickness from 35 to 52 feet, and is quite hard. Shots of from 60 to 100 quarts are used, and some wells have already received the second charge.

The second pool, near Homeworth, lies southeast of the village, and was discovered in July, 1900. This first well was located on land of the Brooks heirs, and began producing 30 barrels per day. Work has been progressing since that time, and by August, 1901, twenty wells had been drilled. These are larger producers than those in the pool previously described, the best starting at 30 barrels or more per day. But two dry holes have been drilled thus far. The production is derived entirely from the Berea grit, which has a thickness of 50 feet. The pay-rock lies at the bottom of the formation, and is frequently separated from the sand above by a bed of slate from 6 to 8 feet thick. The sand is softer than that in the north pool, and is shot with from 10 to 50 quarts.

Lying east of the village and between the two pools previously noted are several gas wells having a closed pressure of from 200 to 225 pounds per square inch. By far the greater part of the production is piped to Alliance, where it is used in the works of the Morgan Engineering Company. The gas is derived from the Berea sand. Besides these wells a number of dry holes have been drilled, one reaching a depth of 1,400 feet, or about 700 feet below the Berea. Neither oil nor gas was found below the sand just named.

West Township.—A dry hole was drilled on the Simms farm at East Rochester in the winter of 1900-1901. The Berea grit is reported to have been struck at 725 feet, and to be 42 feet thick.

Hanover Township.—In the spring of 1900 a Berea well was drilled two miles east of Hanoverton, but nothing more than a large quantity of salt-water was found. About the same time a Berea well was drilled two miles southeast of Hanoverton, and made a showing of a heavy oil. This was bailed for a short time, but was never pumped.

Washington Township.—A deep well is reported to have been drilled near Salineville in the fall of 1900. The Berea was found at about 800 feet, but hope was not abandoned until a depth approximating 3,200 feet was reached.

PERRY COUNTY.

A large amount of drilling has been done in this county, the objective stratum being in nearly every case the Berea grit. Quite recently a deep well has been drilled to the Clinton sand near Junction City, and the small quantity of oil found was sufficient to encourage another test, which is now in progress. A record of the completed well has been given in the chapter treating of the Central Ohio Natural Gas Fields. Thus far only one field of importance has been discovered in the county, and that is reviewed below.

THE CORNING OIL AND GAS FIELD.

Location and Area.—This field lies in the three counties, Athens, Perry and Morgan. Leaving out of consideration at present a few small outlying pools, and starting at the south, the productive territory may be said to begin in section 22, Trimble township, Athens county. From this point it runs almost due north to the Perry county line. The widest part of this portion of the field does not exceed one-half mile, while the narrowest portion permits of a single row only of wells.

It enters Monroe township, Perry county, in section 33, and runs almost due north towards Corning, but bends to the northeast about one mile south of that place. Here the productive territory attains a maximum width of 3 miles, the greatest in the field. The northeast course is continued to the Morgan county line, where it turns due north, skirting

that line with a productive strip about one-half mile wide for 2½ miles, when it turns slightly to the east, entering Morgan county in section 31 of Deerfield township. From that place it extends through section 30 and into section 19, beyond which oil has not been found. Development of this part of the field is retarded by floods of salt-water, which limit it in this direction. The total length of the field is about 14 miles.

Outside of this belt are four pools, two of which are of little importance. One lies around Glouster, and has an area of less than one square mile. A second one lies in sections 22 and 29, a short distance northwest of Glouster. This is the principal territory from which the gas of Corning and surrounding towns is derived. A third pool lies around Porterville, and the fourth, known as the Oakfield, lies from 3 to 5 miles north of Corning. It includes parts of sections 5, 21, 28, 29, 32 and 33 of Pleasant and 22, 27 and 34 of Bearfield townships. This part of the field was developed in 1900.

Discovery.—Probably the first deep well drilled in the Sunday Creek valley was near Burr Oak, about 4 miles south of Corning. Its date is not now known, but it must have been 40 or more years ago. Its depth is likewise unknown, but it is reported to have penetrated the Salt sand. To this day it flows salt-water, and with it sufficient gas to be ignited. This well, however, seems not to have aroused suspicion that there might be valuable liquids other than salt-water buried in the rocks.

The discovery of oil in the Corning field was a matter of accident, and resulted directly from a scarcity of water for the Toledo and Ohio Central railroad. To remedy this a deep well was drilled in August, 1891, at the round-house, about three-fourths of a mile south of Corning. The only water found was in the Salt sand, which is reported to have been struck at a depth of 630 feet. The supply was copious, but the salinity prevented its being used in locomotives. This brine was shut out of the well by casing and the drill forced down to a depth of 1,507 feet. Finding no water at that depth work ceased, but a few days later oil was thrown to the top of the derrick, and there were smaller eruptions later. However, further disturbances of this sort were prevented by the company closing the well.

Development.—The disclosure made by this well attracted the attention of oil men, who immediately entered the field and began leasing territory. The citizens of Corning feared the land was falling into the hands of the Standard Oil Company, and that it might not under such conditions be developed for years. Accordingly a home company, styled "The Sunday Creek Oil and Gas Company," was organized in February, 1892, to make certain the development of the territory. The capital stock was placed at $10,000 in shares of $50, and $8,900 of the stock was sold. Much of this was raised by citizens of the town subscribing for single shares.

The new company was successful. By January 1st, 1898, 255 per cent. in dividends had actually been paid to the stockholders. In September, 1898, a power for pumping the wells, and costing over $7,000, was erected, the contractor taking the product of the wells until it paid for the plant. In November, 1899, the property, together with $1,250—the amount received in excess of the cost of the plant—was turned over to the original holders. On July 1, 1900, the power was pumping 20 wells, which had a daily production of 40 barrels.

The first well drilled by this company was on the William Fisher farm in northwest quarter section 14, Monroe township, Perry county. The Berea was struck at 1,012 feet, but the indications were so unfavorable for a paying well that it was not considered advisable to shoot it. However, on June 2d, 1892, after waiting nearly a month, the well was shot with 80 quarts of nitro-glycerine, which had been hauled from Sistersville, W. Va. The cost of the shot was $200. The first day following the shooting of the well it produced 12 barrels, and a year later was still producing 10 barrels per day. Following this other wells were drilled in sections 14 and 15. In all 25 have been drilled, only 3 of which were dry holes.

Other companies began work and the territory was rapidly leased and tested. Naturally, operations began near the round-house, where oil had first been shown to exist. From this as a center the drill moved out in all directions until the limits of the field had been disclosed. The later work has been along the northeast end of the territory, in Morgan county, where the oil seems to be shut out by reservoirs of salt-water. During the summer of 1900 the valuable pool in the Oakfield district was developed, though small wells had been found there several years earlier. The principal farms are the Porter, Longstreth, Donnelly, Monahan, McDonald and Grannan. The first well was on the Porter farm and was finished early in 1900. Its production was 35 barrels the first day. The second well was on the Monahan farm. It was completed soon after the Porter well and had an initial flow of 45 barrels in 24 hours. The next two wells were drilled on the Longstreth farm, and both were fair producers. Early in the spring a well was completed on the Donnelly farm and flowed 125 barrels the first day. Other wells on this farm are much smaller. Two wells on the Grannan farm began flowing 75 and 90 barrels respectively. It is interesting to note that the development of this, the richest part of the Corning field, occurred late in the territory's history.

An important step in the development of the field occurred on August 13th, 1893, when the Buckeye Pipe Line was completed. Before that the oil was transported by tank cars. The oil is brought to the tanks partly by gravity and partly by suction, the latter being produced by an 8 horsepower gas engine, and is stored in two iron tanks, one of which has a capacity of 30,000, and the other of 28,000 barrels. From these tanks the

oil is forced to Elba, a distance of 34 miles, through a 4-inch line. This work is done by a 35 horse-power engine, which gives a pressure in the line of from 700 to 1,000 pounds per square inch. The rate at which the oil is transported varies with the temperature. In the summer, when the oil is warm, and hence thin, 128 barrels may be pumped in one hour, but in the winter, when the oil is cold and thick, the transportation may be restricted to 11 barrels for the same period.

When the pipe line was completed the production of the field was about 500 barrels per day. It increased to 1,300 barrels in 1896, but since then has declined. In June, 1900, it ranged from 800 to 900 barrels per day, but had dropped to 352 barrels in July, 1902.

Production.—The production of the field has been as follows, according to data furnished by J. R. Campbell, Treasurer of the Buckeye Pipe Line Company, Macksburg Division:

	Barrels.
Part of Year 1893	128,918.03
Year 1894	322,313.71
Year 1895	428,385.03
Year 1896	469,258.78
Year 1897	328,188.11
Year 1898	196,417.75
Year 1899	211,060.22
Year 1900	256,586.99
Year 1901	200,081.07
Year 1902	140,527.98

Leases.—At first the operators paid no bonuses, but gave a royalty of one-eighth of the oil to the land-owners—a rate that has been usually maintained. To this there is one exception worthy of note. When the round-house well showed the existence of oil, and operators began leasing the surrounding territory, Frederick Weaver, a thrifty German farmer, residing a short distance east of the round-house, quietly visited the oil fields of Washington, Pennsylvania, and investigated the methods of leasing oil territory in that field. When he returned home he demanded a royalty of one-fourth the oil and a bonus of $200 for each of the eight wells which it was proposed should be drilled on his farm of eighty acres, and since his territory was regarded as very promising, these rather severe terms were granted. However, after drilling six wells, and the terrritory not meeting expectations, the contractors complained and Mr. Weaver generously reduced the bonus. More recently a royalty of one-sixth the oil has been received by holders of lands that were deemed especially promising, and bonuses also have been paid. The leases usually required that a well be drilled in from thirty to sixty days, but sometimes, especially in the least promising territory, six months were allowed.

That the field was a monopoly for no one is shown by the following list, which includes the chief operators of the district:

Corning Oil Company;	L. D. Langmade;
Denman & Thompson;	Harrington Brothers;
O'Connel Oil Company;	Ohio Oil Company;
Brooks Oil Company;	Church Oil Company;
Caldron & Snyder;	Monroe Oil & Gas Company;
Sunday Creek Oil & Gas Company;	Weaver Brothers;
Perry County Oil Company;	W. B. Irwin & Company;
W. B. Barker & Company;	George Best & Company;
Cleveland Oil Company;	Foster & Moran;
Keystone Oil Company;	Fallen Rock Company;
W. E. Detlor;	Ohlviler & Chambers;
William Rosier;	Mill Oil Company;
J. H. Van Wormer;	Hemlock Oil Company;
Northeast Oil Company;	John Holden;
Becker Oil Company;	Wells & Foraker;
Allen, Sternberg & Company;	Longfellow & Stevens;
Bolivar Oil Company;	Russell Metzger;
William McMullen;	McGee & Stewart;
A. Bulger & Company;	Stratton & Mark.
Corning Natural Gas Company;	National Oil Company.

Geology of the Region.—The surface of the territory lies in the Lower Productive and Lower Barren Coal Measures. The highest hills reach up to or extend above the Ames or Crinoidal limestone. In fact, along the northeast extremity of the field the hills are capped by the limestones, which underlie the Pittsburg coal. The deepest valley—that of Sunday Creek—cuts through the Middle Kittanning coal, a short distance north of Corning, but at this town the seam named is under cover, while the Upper Freeport coal is at about drainage level.

The succession of strata under ground is shown by the following record kept and furnished the Survey by Mr. G. W. Delong, Superintendent of Schools, Corning. The well is located on lot 154 of the town just named, and the top of the well lies at the base of the Mahoning sandstone:

	Thickness of stratum. Feet.	Total thickness. Feet.
Shale	25	25
Bastard lime	15	40
Sand	10	50
Coal (No. 6)	10	60
White slate	65	125
Sand	15	140
White slate	25	165
Blue	10	175
Sand	10	185
Slate	50	235
Shale	35	270
Sand	30	300

	Thickness of stratum. Feet.	Total thickness. Feet.
Black shale	10	310
Lime	25	335
Shale with concretions	100	435
Slate	25	460
Limestone (?)	30	490
Shale	35	525
Salt sand	30	555
White slate	100	655
Slate and concretions	25	680
Shale	15	695
Little Salt sand (Big Injun)	20	715
White slate	100	815
Slate and concretions	100	915
Brown shale	40	955
Black shale (*Berea*)	38	993
Top of *Berea*		993
Bottom of *Berea*		1,008

The Oil Sand.—This is in all cases the Berea. It has the light gray color so common in this formation in other parts of the state. It is moderately fine grained, but there is considerable variation in this respect. Usually it is a pure quartz sand, but occasionally has thin layers of dark shaley material running through it. In thickness it shows considerable variation, but never disappears in this field. The normal thickness is usually given as twenty feet and the maximum reported is eighty. This depth was found on the Potts farm about one and one-fourth miles northeast of Corning, and on the O'Farrell farm about two miles east from the same town. In both cases a dark gray shale, probably the Ohio, lay below. The Bedford on this theory had been swept away before the Berea was deposited. In such abnormal depths the additions always appear to be on the bottom, showing that the surface of the underlying Bedford shale was quite uneven. It is worthy of note that the production of oil does not vary as the thickness of the sand. In fact, in this field the great thicknesses are generally poor producers.

The pay-streak, or that containing the oil and gas, ranges in thickness from 3 to 8 feet, but very few wells attain the maximum figure. Towards the margin of the productive field the pay-streak thins, and finally disappears. The top of this usually lies from 10 to 15 feet below the surface of the Berea. As a rule the pay is coarser than other parts of the Berea, and generally the coarser the rock the larger the well. Sometimes in the thick part of the Berea there are two pay-streaks.

The Oil Wells.—The number of wells producing July 1, 1900, exceeded 600; August 1, 1902, it was 688. About 100 dry holes have been drilled and about an equal number of wells have been abandoned, so that 900 is a fair approximation of the total number of wells drilled. As a rule a well has been put down for each 8 or 10 acres of surface territory.

The wells have been cased through the Salt sand, a depth of 555 feet in the valley at Corning. The casing has almost invariably been 5⅝ inches, inside measurement. The rocks comprising the underlying 160-180 feet, and terminating with the "Little Salt sand," have furnished some water, which has been disastrous to the wells. It reduced the gas pressure, thus necessitating pumping earlier than otherwise would have been required, and perhaps prematurely destroying the life of the well. Had the wells been cased through this sand time and money would have been saved, and the production of the field would have been larger.

The western side of the field is quite free from salt-water. It is on that side that the principal gas territory lies. On the eastern side the conditions are more variable. In Trimble township, Athens county, the wells are free from water, while in Monroe township, Perry county, salt-water is found in the northeast corner, and in Morgan county it is so abundant that operating is prevented. From this it appears that the western side of the Corning field is free from salt-water, and that it is absent also on the eastern side at the southern margin of the territory, but that it increases rapidly to the northeast.

While the production of the wells after being shot has varied greatly, yet they have not furnished the extremes that many other fields have. Few, if any of the wells, have started better than 125 barrels per day, and it has been estimated that the average for the entire field has beeen 20 barrels.

The wells have sufficient gas pressure to flow them during the earlier part of their lives, but later as the pressure diminishes they have to be pumped. Since the eastern side of the field has salt-water the wells there have to be pumped earlier than those on the western side.

The Gas Wells.—The principal gas territory is that along Muddy Fork in sections 22 and 29, Trimble township, Athens county, the best wells being found in the western half of the latter section on lands of the Hocking Coal and Railroad Company. The largest well in this field started at 3,000,000 cubic feet per day with a rock pressure of 400 pounds. It was drilled in the fall of 1897, and one year later was producing 2,000,000 cubic feet per day, and still another year later 1,500,000 cubic feet. Of the other wells in this territory two started at 2,000,000 cubic feet each, two at 1,000,000 feet each, and three at 500,000 feet each. The decline in the smaller wells was not as rapid as in the larger ones, since the demands made on them were not as heavy. The reliance of the community is on this field, where 5,000 acres are leased in one block. In 1902 the rock pressure had decreased to 200 pounds.

Another district that has yielded considerable gas is that at Oakfield, about 3 miles north of Corning. These wells started at 2,000,000, 1,500,000 500,000 and 250,000 cubic feet per day respectively. Two of the smaller of these have been abandoned after having produced for two years. The largest

of these wells when 4 years old was producing 500,000 cubic feet per day. and the second largest when three years old was producing the same amount. These wells produce considerable oil and by some are rated as oil wells.

Outside of these two places an occasional strip is found that produces gas in paying quantities. Thus about one mile northeast of Corning two wells were drilled, which combined produced 500,000 cubic feet per day. They produced three years and were then abandoned. About two miles north of Corning a good well was drilled on the Newberry farm. It started at 1,500,000 cubic feet per day, had an initial rock pressure of 400 pounds and lasted three years.

Another productive tract lies about 6 miles northeast of Corning on the Finley, Devore and Stoneburner farms. Three wells were drilled on the Finley farm, and started one at 1,500,000 and two at 250,000 cubic feet, with an initial rock pressure of 400 pounds. These wells lasted three years.

The operators of the wells have been much troubled with salt-water in the Muddy Fork field and with oil in the Oakfield territory. Salt-water is removed by "blowing" the wells. For this operation the wells are closed for a short period, usually about 30 minutes, allowing the gas pressure to increase; when this has become sufficiently strong the well is opened at the top and the gas then blows the water from the well. When the well has been cleansed in this manner it is closed and the gas turned back into the mains. Sometimes, however, the weight of the water is so great that the gas cannot drive it from the well in the manner just stated; especially is this true with wells that have been in use for a considerable period. Then an iron rod attached to a long pole is let down through the water, is raised and lowered, and the gas following the pole in its ascent finally drives the water from the well. This method of cleaning is known as "agitating." Finally the pressure of the gas becomes so small that it cannot lift the water with the help of "agitating," and then the well is dead. In winter time each well is cleaned every other day, and in the summer twice a week.

The gas wells in the Corning field were owned and operated by the Corning Natural Gas Company, but recently they became the property of the Ohio Fuel Supply Company. It supplies Jacksonville, Trimble, Glouster, Murray City, New Straitsville, Shawnee, Hemlock, Corning, Rendville, Moxahala, New Lexington, Nelsonville and several interior hamlets. Almost the sole use of the fuel is for heat and light for domestic purposes.

The company made a rate of 20 cents per thousand feet by meter.[1] Where the meter was not used, the prices in winter were $2.00 per month for the first fire; $1.50 for the second; $1.00 for the third; 75 cents for the fourth, and all additional fires at the latter figure. In the summer a

[1]The meter system seems to have been optional until October 1, 1901.

charge of $1.50 for each cooking fire was made. For lights the charges were 25 cents each for the first two and 15 cents for each additional one. On October 1, 1901, the company adopted the meter system, the rate being 20 cents per thousand. The effect of this was economy in the use of gas, so that there was a supply for all, whereas before the supply was inadequate during cold weather. The change met with much opposition at first, but this was short-lived, and the wisdom of the new plan is now generaly admitted.

The number of families supplied (1900) exclusive of Nelsonville, is approximately as follows:

Corning	300
Glouster	250
New Lexington	250
Shawnee	200
New Straitsville	150
Other places	350
Total	1,500

MUSKINGUM COUNTY.

This has never been an important producer of oil or gas. Nevertheless it must be ranked among the pioneer counties of the state in oil production. Few areas, too, outside of the large producers, have been more thoroughly tested. "Wells have been located in all the ways that can be suggested, viz., at the caprice of the drillers, at random, in the neighborhoods of the famous blowers of the salt-water days, and lastly, with all the aid that geology can give, on the summits of the low arches and terraces which the spirit level reveals, and the records of all agree as to the outcome. The order and character of the strata are remarkably uniform and regular, but there is nothing whatever to break the monotonous returns of complete and unrelieved failure. There is a little gas or oil, or both, everywhere, but the fatal flood of salt water is always just at hand, and the most brilliant promise is speedily extinguished by it."[1]

Zanesville and Vicinity.—In 1884 the Zanesville Heating Company drilled a well in the valley of the river in Putnam. The well head was just below the Lower Mercer limestone. The Berea sand, having a thickness of 20 feet, was found at a depth of 840 feet, and was charged with oil. Work continued until the shales lying below the Berea had been penetrated to a depth of 1,149 feet, but without finding beds of sand or reaching the great limestone below. The well was a failure. A second well was begun soon. It was located two miles south of the city on the Bishop land in section 4 of Wayne township. The Berea sand was struck at a depth of 847 feet, and was 33 feet thick. It yielded a little oil and gas, but not sufficient for commercial purposes. In the spring of 1897 a well was drilled on the

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 376.

Fox farm about one mile east of Zanesville. The Berea made a small show of gas and with it much salt-water. From Zanesville the search has continued in all directions, and the various townships will be reviewed to show the thoroughness with which the tests have been made.

Blue Rock Township.—Pioneers of this township observed gas bubbling on the headwaters of Mann's Fork, and after oil had been discovered at Macksburg and Cow Run it was decided to drill a deep well in the hope of finding a pool of oil. The first well was drilled on the Daniel Border farm, and a show of oil was found at a depth of 80 feet. The next well, known as the Woodbury, was drilled on the Joseph McDonald farm. At a depth approximating 75 feet oil was found. The yield at first was from 40 to 50 barrels per day, but the decrease was rapid and by the end of perhaps two years the well was abandoned. This success started a boom, and it is estimated that within a year a hundred wells had been drilled in that locality. A hamlet known as Oil City, and with it the usual proportion of boarding-houses and saloons soon appeared. Within a year, however, it was found that the pool was small and the wells short lived. Soon the field was abandoned, and the only evidence now found of the former activity is an occasional piece of scrap iron, the remains of some crude drill or pump. Landholders received a royalty of one-fourth the oil, but notwithstanding this heavy ratio large bonuses in addition were sometimes paid. Several tracts, too, were sold at exorbitant prices, one piece of 13 acres commanding $13,000. The oil is reported to have had a gravity of 26 degrees B. and to have been an excellent lubricator. The producing sand ranges in thicknes from 2 to 30 feet, and lies about 70 feet below the "fossil" or Ames limestone. From this it appears that the oil sand is the First Cow Run. About 1870 an effort was made to drill a deep well in this territory, but at a depth of 500 feet the tools became fast and the well was abandoned. In the fall of 1900 two shallow wells were drilled on the Border farm, already mentioned. These were pumped a short time and then abandoned. In 1901 two wells were drilled near Rural Dale, but both were failures.

In 1886 Carr Brothers and Jewett drilled a well in section 32. The Berea sand, having a thickness of 14 feet, was found at 1,074 feet. It was torpedoed with 80 quarts of nitro-glycerine and made a good show of both oil and gas.[1] This was sufficient to encourage further exploration, and in 1887 a well was sunk on the Durant farm in section 31. The Berea was found 30 feet in thickness, but was of poor quality. It made a show of oil, but was abandoned without having been shot. About the same time a test was made along the river, one and one-half miles south of Gaysport. The Berea was reported 5 feet thick. The well was shot and made sufficient oil to warrant pumping, but in a short time salt-water ruined it. In the fall of 1900 a well was drilled on the Peyton farm, about two miles east

[1] *Geol. Sur. of Ohio*, Vol. VI, p. 375.

of Gaysport. At a depth approximating 500 feet a show of oil was found, but the well was abandoned without reaching the Berea sand. Early in 1901 a well was drilled in the southern part of the township on the Finney land. The Berea made a show of gas, but this was overcome by a heavy charge of salt-water. About the same time two wells were drilled 3 miles east of Gaysport, one on the Cohagan and the other on the Shaver farms. Both were failures. In this part of the county, as well as farther south in Morgan, the Berea is divided. The relations are reported as follows:

Sandstone, 12-15 feet.
Shales, 6-15 feet.
Sandstone, 12-20 feet.

The drillers apply the name Berea to the upper division only, the lower one being known as the "stray." One experienced driller reports that the sand separating the two has a red color, a character indicating that it belongs to the Bedford. Oil and gas when found are in the upper division.

Brush Creek Township.—About 1897 a well was drilled on the Swingle farm in section 8. It was located on the bank of Brush creek and reached the Berea sand at a depth of 1,096 feet. Considerable gas with some oil was found, and the well was pumped a short time. In 1899 a well was drilled on the Longshore farm in section 15. A skeleton record of this well, furnished by T. P. Connar, is as follows:

	Thickness of formation. Feet.	Depth to bottom of formation. Feet.
Putnam Hill limestone	3	23
Sub-Carboniferous limestone	40	265
Big Injun sand	40	630
Berea shale	33	952
Berea sand	28	980
Bedford shale	30	1,010

Bottom of well at 1,030 feet.

All measurements were made with a steel line.

The Berea made a show of oil, and with it some salt-water. In 1900 a well was drilled on the Swingle farm in section 9. The sand was found at 1,155 feet, and produced some oil and gas. After having been torpedoed with 80 quarts of nitro-glycerine it began flowing oil and is said to have produced between 200 and 300 barrels. It was never pumped. Within the same year a well was drilled on the Boyd farm in the same section. It made some gas and a small quantity of dark colored oil. The well was abandoned. Mr. Connar reports a reversal of dip in this locality, the dip to the west being 24 feet in less than one and one-half miles. On the eastern side of the arch the dip is 65 to 68 feet per mile. The wells are on the west side of the arch.

Harrison Township.—In 1900 a well was drilled on the Durant farm in section 31. The Berea sand found was of poor quality, and contained salt water, but neither oil nor gas. In the same year a well was drilled near Cedar Run P. O. on the bank of the Muskingum river. The Berea was reached, but contained neither product sought.

Newton Township.—On the Beem farm in section 34 a well was drilled in 1897. The Berea sand, 11 feet thick, was found 887 feet below the surface. Both oil and gas were found but not in commercial quantities, and the well was abandoned without having been torpedoed.

Cass Township.—A well was drilled at Dresden in 1886. The Berea sand having a thickness of 14 feet was found 768 feet below the valley, and contained oil and brine. Work continued until several hundred feet of the Ohio shales had been passed through, and then not having met with any further encouragement the well was abandoned.

Meigs Township.—At least two deep wells have been drilled in this township. One located on the Bethel farm is reported to have produced some gas, and to have made a show of oil. Data concerning this well are very meager. It is probable, however, that the Berea sand was reached. About the year 1893 a well was drilled on the Simms farm 4 miles east of High Hill. A depth approximating 1,700 feet was attained. The sand made a show of oil, but the well was abandoned without having been shot.

Salt Creek Township.—About 1892 a well was drilled on the Cline farm in section 28. The Berea sand was found at a depth approximating 1,085 feet, but contained neither oil nor gas in commercial quantities. About the same time a well was drilled on the Murphy farm in section 28. Nothing better than a show of oil was secured. Neither of these wells was troubled with much salt-water. A well was drilled near the same time on the Evans farm in section 33. The Berea contained some black oil, but the well like the others in the township was abandoned.

Perry Township.—About 1898 a deep well was drilled near the village of Sonora. The sand contained salt-water, but neither oil nor gas.

Rich Hill Township.—Three wells have been drilled near Freeland within the past few years. One on the Abraham Howell land found the Berea at 1,350 feet. The sand was not drilled through. It made a good showing of oil, but was not pumped. Similar results were had in the other two wells.

Jackson Township.—The only deep well ever drilled in this township was located about three miles north of Frazersburg on land now owned by William Normans. A depth of 760 feet is reported. It produced much salt-water and a show of gas. This well is said to have been drilled more than 30 years ago.

Licking Township.–In 1901 a well was drilled on land of John Nether in lot 12. The Berea is said to have been drilled through, but nothing of value was secured.

Salem Township.–In 1899 a well was drilled on land of E. B. Shivers two miles east of Adamsville. The Berea grit, 20 feet thick, was found at 1,176 feet. It made a showing of oil and gas and much salt-water. In the same year a well was drilled on the farm of C. A. Geyer near Adamsville. The Berea was found at 1,200, and was 28 feet thick. Total depth, 1,255 feet. The results were similar to those of the preceding well. Both wells were shot with 60 quarts of nitro-glycerine.

ATHENS COUNTY.

This discussion will include all townships of this county except Trimble, which forms part of the Corning field, and Ames and Berne, which have been discussed in connection with Morgan county.

Athens Township.–The earliest wells of which report was received were drilled along Sugar creek in the northern part of the township, many years ago, perhaps about 1865. No positive information was received as to the depths of these. One is reported to have produced a small quantity of oil.

Of the recent wells drilled in this township the first was on the farm of J. T. Hope, about one and one-half miles west of Athens, in the fall of 1895. The depth of this well was 1,050 feet and the thickness of the Berea 40 feet. The well produced considerable gas, but no oil. The middle of the Berea was charged with salt-water. No use was made of the gas, and so the casing was withdrawn and the well abandoned.

In December of the same year a well was drilled in the Stroud's Run field on the C. A. Snow farm, about 3 miles northeast from the court house. This point is on a line extending from the oil wells in Trimble township to several small gas wells southeast of Athens, and for this reason it was thought that the location might be in productive territory. The depth of this well was 1,250 feet. It showed some oil and gas, and the production was increased by shooting with 40 quarts of nitroglycerine. Another well in this field was drilled in April, 1896, 2 miles north of the last one on the F. L. Junod farm, and was dry. On May 30, 1896, a well was completed on land belonging to George Slaughter, about 1,000 feet west of north of the one on the Hope farm. It produced a small amount of gas, but no oil. In the fall of 1896 a second well was drilled on the C. A. Snow farm, about 500 feet east of south of the first well drilled. Some oil was found, but this was driven out by a flood of salt-water, and the well was abandoned without having been shot. Two wells were drilled in this field in 1900, one of which was producing 12 barrels per day on July 1st, but the other one had not been tubed at that time. It is safe to say that the production of this field, which occupies a fraction only of one mile, does not exceed 25 barrels per day. Quite recently a two-inch pipe line has been laid

by the Buckeye Pipe Line Company, connecting this field with the B. & O. railroad just east of Athens. From that point the oil is hauled in tank cars to Parkersburg, the charge being 15 cents per barrel. In September, 1902, the 4 wells in this field were making all told about 10 barrels per day.

The bottom of the Berea sand is charged with brine, and so the drill is not driven through it. Usually the sand is penetrated to a depth of from 15 to 18 feet. Thus far the show of oil in the field has been simply enough to make certain further explorations, and in the autumn of 1899 the Athens Oil and Gas Company was formed to develop this territory, of which it had 700 acres leased.

Several wells have been drilled within the past few years on the Children's Home farm, just outside of the Athens corporation, and on lots within the city limits. In January, 1897, a well was drilled on the Home farm, about 300 feet north of the Hocking river. The Berea was found at 1,135 feet, and contained water charged with salt. When the Berea was penetrated a show of oil and gas was found, and this was materially increased by shooting the well with 40 quarts of nitro-glycerine. The well was pumped about 30 days, after which it was tubed when it began flowing. The yield of oil was about 2 barrels, and of gas about 75,000 cubic feet per day. It is claimed that the yield of these products at the present time is similar to that at the beginning. Another well was drilled on the Home farm in June, 1897, and practically duplicates the one previously reported.

Two wells were drilled near Mills street in Athens in the summer of 1898. Both produced oil and gas, but the latter was not sufficiently strong to force the oil to the surface and so the well had to be pumped. The two conjointly produced one barrel of oil per day. The gas is turned into the city mains.

In the summer of 1898 a well was drilled on the Grovernor farm just north of the Home, but the Berea sand was wanting and the well consequently dry.

Two wells have been drilled on the grounds of the Athens Brick Company. The first, which was finished in April, 1898, struck the pay-rock at a depth of 1,144 feet. It produced no oil, but yielded sufficient gas to supply a dozen residences. The second well, finished in August, 1898, duplicated the first one, except that it was even smaller. Because of the fear of salt-water the first well was never shot, but the second one was shot with 35 quarts.

Waterloo Township.—With the exception of Athens and Trimble more deep wells have been drilled in Waterloo township than in any other one in Athens county.

The stratigraphical relations are shown by the following record of a well located one mile northwest of Marshfield. Mr. W. R. O'Neill, well contractor, has kindly furnished the Survey with the data.

	Thickness of stratum. Feet.	Total depth. Feet.
Surface material	19	19
Shale	81	100
Soft white sand	65	165
Coal	7	172
Shale	112	280
Coal	10	290
Shale	285	575
Soft sand	10	585
Shale	85	670
Shale	472	1,142
Berea sand	30	1,172
Shale	10	1,182
Berea sand	40	1,222
Shale	772	2,000
Brown shale	350	2,350
Shale	100	2,450
Brown shale	68	2,518
Corniferous and Lower Helderberg lime	200	2,718

It will be noted that according to this report the Berea consists of two strata separated by ten feet of shale, a condition that becomes quite conspicuous in Morgan county and other places. This well was a failure.

Following is the record of a well one mile south of Mineral on the farm of Henry Graham, finished June 6, 1900; furnished by Mr. W. R. O'Neill, well contractor.

	Thickness of stratum. Feet.	Total depth. Feet.
Surface	20	20
Slate	95	115
Sand	125	240
Slate	30	270
Sand	30	300
Red Rock	10	310
Limestone	40	350
Slate	20	370
Sand	50	420
Slate	20	440
Limestone	40	480
Sand	60	540
Slate	140	680
Sand	40	720
Slate	70	790
Limestone	60	850
Slate	50	900
Sand	40	940
Limestone	20	960
Slate	50	1,010
Brown slate	18	1,028
Berea sand	27	1,055
Bedford shale	5	1,060

To the above may be added the following additional record of a well drilled in the same vicinity by the Ohio Oil Company.

	Feet.	Feet.
Berea grit	34	1,041
Ohio shales	1,230	2,271
Helderberg and Niagara limestones	816	3,087
Clinton Series—Brown shales	15	
Red shales	10	
Shales	124	3,236
Medina shales (red)	10	3,246
Light gray shale	9	3,255

The company was drilling for the Clinton sand, but as shown this was not present, its place being occupied by shales.

Other deep wells in this township have been sunk in sections 17, 18, 19 and 25. In fact this territory and the adjoining parts of the counties on the west and south have been tested by the Ohio Oil Company, which has extensive leases in this part of the state. The result of these tests has been to demonstrate that oil and gas are not found in paying quantities in the territory under consideration. There are rumors and reports of good wells in Waterloo township, but there is good reason to believe that the best wells do not poduce more than three barrels per day.

York Township.—Three wells have been drilled here and all were failures. One was located in section 1, another at Nelsonville, and the third near Buchtel.

Lee Township.—Two wells have been drilled in this township, one on the John Elliot farm in section 17, which was dry, and the other in the village of Albany. The latter one made a showing of dark oil, but the quantity was so small that the well was abandoned.

Alexander Township.—Three Berea wells have been drilled in this township. One at Hebardsville on land owned by Henry Merick, drilled in the autumn of 1895, made a good showing of heavy oil, but the production was not sufficiently large to warrant operating, and so the well was abandoned.

In the winter of 1895 a well was drilled on the Cooley farm, situated about 2 miles south of Hebardsville, and a good flow of gas was found. This is reported to have been measured by the mercury gauge, and to have produced 1,222,000 cubic feet per day. Not satisfied with this the operator proceeded to drill deeper, but struck a heavy flow of salt-water which ruined the well. The third well was drilled at Zelda, but was dry.

Canaan Township.—A well was drilled on section 34 in the autumn of 1896. The Berea was struck at about 1,220 feet, and was 24 feet thick. It was underlaid by the red Bedford. In attempting to shoot the well, the 40

quarts of nitro-glycerine were accidentally discharged at a depth of about 900 feet, bursting the casing and necessitating the abandonment of the well. Before shooting, the well is reported to have made a good show of both oil and gas. In 1898 a well was drilled in section 33, and began flowing 5 barrels per day. In 1899 a second well was begun in this section, but at a depth of 470 feet gas was struck and the wells were connected with the Athens mains. The company expected to drill the well to the Berea later.

Dover Township.—Three Berea wells have been drilled here. They were located in sections 1 and 2 and along the Athens township line near where the Hocking river leaves Dover. Nothing more than a small flow of gas was found, and the wells were abandoned.

Lodi Township.—A Berea well has been drilled on the farm of Lewis Jeffers about one mile north of Shade P. O. At a depth of about 500 feet considerable gas was found, but when the well was extended to the Berea neither oil nor gas was present. Two wells have been drilled near Hull P.O. , in the eastern part of the township. The first was on the farm of Geo. R. Lawrence, just east of the village named. The Berea is reported divided there as shown below:

	Feet.
Sand	25
Slate	25
Sand	25

Oil, gas and salt-water were all found in the upper sand, and in the lower one the gas was so strong that it cleaned the well. No use was made of it however, and the well was abandoned. A well has been drilled on the Eliza Hull property in the village of Hull P. O. The well was cased through the top of the Berea and shot with 60 quarts of nitro-glycerine, but because of an accident the well was abandoned. A Berea well has been drilled in section 12, and another one across the line in Carthage township in section 35, less than a mile northeast of Hull. Neither of these made more than show of oil or gas.

Troy Township.-A Berea well was drilled on the Shepard Humphrey farm one mile south of Coolville about 1898. The hole was dry and was abandoned without shooting. Another failure was recorded in a well one-half mile west from the same village. It made a small showing of oil, but was never shot.

Rome Township.-The only Berea well in this township was located on the northeast quarter of section 31. Like nearly all the wells in the county it was a failure.

Summary for County.—More than 50 wells have been drilled to the Berea and not one good producer found. It is safe to say that the total production of these wells is less than 35 barrels per day. The companies which have recently been or are now (1900) operating in the field are the following:

Shepp Oil Co.
Athens Brick Co.
Ohio Oil Co.
Bradley and Co.
Paova Oil and Gas Co.
Athens Gas and Oil Co.
Hocking Oil Co.

Remembering that one or more Berea wells have been drilled in each township with the results as recorded, it seems safe to say that no large pools of Berea oil lie within the limits of the county.

HOCKING COUNTY.

A large number of wells have been drilled in this county. In 1865 and 1867 three tests were made to the Berea grit at Logan. The top of the wells was at the horizon of the Logan Conglomerate, and the Berea was reached at about 600 feet. All yielded a small quantity of heavy oil, and from one the production was continued for several years. In 1887 another test was made at the county seat, and the result was similar to that obtained from the earlier wells.[1]

About the time that the early wells were drilled at Logan three tests were made of the Berea grit near Bloomingville, Benton township. The sand was struck at a depth of about 500 feet, with results similar to those in Logan. In 1882 another well was drilled in the same vicinity, the Berea again producing a small quantity of both oil and gas. No use was made of either, however. In 1896 a company of McArthur citizens drilled a well in this township. It was located on the Miller farm in section 33, and struck the Berea grit at 526 feet. The sand was penetrated to a depth of 14 feet without reaching the base. After having been shot the well yielded a small quantity of heavy oil of about 26 degrees B. gravity. In 1902 a well was drilled on the Honold farm in section 36. The Berea is reported to have been found at 728 feet, and to have yielded a small quantity of lubricating oil of excellent quality. Both wells contained considerable salt-water in the Berea. Doubtless other wells will be drilled to the same horizon in this township.

Besides the Berea wells one has been sunk to the Clinton. This was in the southern part of the county, just north of the small pool in Jackson township, Vinton county. The well, however, was dry. Two other attempts have been made to reach the Clinton in this part of Hocking county, but both were unsuccessful.

The northern part of the county under consideration has been as productive as other parts have been barren. Reference is made to Good Hope,

[1] *Geol. Sur. of Ohio, Vol. VI., pp.* 391-93.

Laurel and Marion townships, which constitute an important part of the famous Sugar Grove gas field. This has already been considered in that connection, and no further discussion of it is necessary here.

JACKSON COUNTY.

The surface formations of the greater part of this county lie in the Conglomerate Coal Measures, and the Allegheny Formation, or as it has long been known the Lower Productive Measures. Along the western side of the county the Waverly is found. The amount of drilling has not been as extensive as in several adjacent counties. Thus far negative results only have been secured.

Lick Township.—In 1886 a deep well was drilled at the county seat, and a depth of 1,636 feet reached. The Berea grit was found at 750 feet, and has a thickness of about 8 feet. It made a show of oil and gas, sufficient of the latter to supply one residence. The well was not torpedoed. Much salt-water was found in the great limestones lying beneath the Ohio shales. The well head is reported to have been about 50 feet below the Sharon or No. 1 coal. Encouraged by this well another one was begun almost immediately near the western limit of the town, the objective stratum being the Berea. This was found at about 740 feet, and made a show of oil and gas, but neither in quantity to be commercially valuable. No further work has been done in the township.

Wellston Township.—The only test reported here was made at Wellston in the summer of 1902. A depth of 800 feet was reached, which was probably sufficient for the horizon of the Berea grit. The only reward was a small show of oil and gas. The well head is reported at about 85 feet above the Wellston or No. 2 coal.

Liberty Township.—A deep well was drilled by T. N. Barnsdale on the land of I. C. Long in 1898. The top of this well is reported to have been on the horizon of the Sharon or No. 1 coal. It was planned to drill to a depth of 3,300 feet, but work stopped at 2,155 feet, and the well was abandoned, leaving 600 or 700 feet of casing in it.

Scioto Township.—A well has recently been drilled on land of Van Johnson, but without success.

Jackson Township.—Two or more wells are reported in this township, which lies in the northwest corner of the county. A show of oil or gas was secured, sufficient to induce the operators to make more than one test, but the results have been out of proportion to the time and money expended.

It appears in view of wells already drilled that a show of oil or gas can be found in the Berea grit almost anywhere in the county. There is no reason to believe, however, that either of these will be found in quantity ample to be profitable.

Washington Township.—About 1891-2 a well was drilled in the northeast corner of this township near the Baltimore and Ohio railroad. The Berea grit is reported to have been struck at about 900 feet, but was dry.

VINTON COUNTY.

The surface geology in this county is similar to that in Jackson. Along the western margin the Waverly constitutes the surface formation, but elsewhere the coal measures are found. Drilling has been done at times during the past 35 years; at first the Berea was the stratum sought, but when this did not yield satisfactory results deeper holes were drilled. During the past ten years about a dozen tests have been made in the Clinton, the details of which are given under the several townships. Nearly all the deeper wells are found on the western side of the county.

Vinton Township.—The first deep well in the county was located on the John Calvin farm in section 4 of this township. It was drilled in 1867, and struck a heavy flow of gas at 490 feet. The well head is reported to have been near the Ferriferous limestone, and consequently the gas sand could not have been the Berea grit. Probably it belonged in the Logan group. The gas when ignited produced a flame from 75 to 200 feet high, and as late as 1870 showed little or no diminution.[1] About ten years after the well had been drilled, during all of which time gas had been wasting, it was cleaned with the idea of using the gas in the manufacture of lampblack. However the time had passed for such a supply, and the well soon ceased flowing entirely.

In 1895 H. C. Chapman drilled a well about 600 yards north of the pioneer one. The well-head was at about the horizon of the Ferriferous limestone, and the Berea grit was found at 1,015 feet. Both gas and salt water were found in the Big Injun, and the same is true of the Berea. The depth of the well was 1,055 feet, work having stopped when the drill had penetrated a few feet of the shales underlying the Berea.

Below is a log of this well, furnished the Survey by J. M. McGillivray, Esq., of McArthur:

	Thickness of formation. Feet.	Depth to bottom of formation. Feet.
Loam	25	25
Sand	35	60
Coal, 3a	3	63
Limestone	8	71
Black shale	20	91
Sandstone	27	118
Slate	45	163
Sandstone	6	169
Coal, No. 2	2	171
Slate	63	234

[1] *Geol. Sur. of Ohio, Vol. VI., p. 394; also Report of Progress (1870), p. 118.*

	Thickness of formation. Feet.	Depth to bottom of formation. Feet.
Sandstone	21	255
Slate	6	261
Limestone	81	342
Slate	33	375
Sandstone	80	455
Big Injun—Cased at 795 feet	240	795
Shale	220	1,015
Berea sand	38	1,052

In the same year Mr. Chapman drilled a well on section 24. The Berea was struck at about 1,000 feet. It liberated a flood of salt-water and made a show of oil.

In 1899 the Ohio Oil Company drilled two holes in this township; one was near the Eakin well in section 4, the other on the Wyant land in section 13. Both stopped with the Berea grit. A show of oil and much salt-water were secured.

Clinton Township.—About the year 1886-7 a well was drilled at the village Hamden, and the Berea reached at a depth reported at 900 feet. A show of gas and perhaps of oil was the only reward. The salt-water found was in sufficient volume to flow from the well. In 1902 several shallow wells were drilled in this township, and sufficient gas found to warrant piping Hamden. The producing sand lies above the Berea, and probably forms part of the Big Injun series.

Madison Township—About the year 1895 a test was made on the Verigan farm in section 26. The Berea, which was found at about 1,000 feet, made a show of oil and much salt-water.

Brown Township.—But one well has been reported in this township. This was on the Thomas McGee farm in section 34. The work was done about 1895. The Berea was found at approximately 1,000 feet, and made a show of oil and much salt-water.

Richland Township.—In the spring of 1898 a well was drilled on the south side of section 4. Work did not cease until the Clinton sand had been struck, but it yielded neither oil nor gas. Shortly afterwards a well was drilled on land of William Poland in section 28. The Clinton was found at 2,340 feet, and is reported to have made a heavy flow of gas. No use seems to have been made of this fuel, however. This well was followed by another one, located on the Wyatt land in section 9, near the north line of the township. The Clinton sand at first made much gas, but this was soon exhausted. Not satisfied with these results another well was being drilled to the Clinton in the winter of 1902-03.

Jackson Township.—This township contains a small but the best pool of oil that has yet been found in the county. It lies in sections 3 and 4 near the Hocking county line, and was discovered in August, 1899. By

September, 1902, five oil and one gas wells had been secured and two dry holes drilled in this section. Two additional dry holes have been drilled to the Clinton in this vicinity; one on the McNichols farm in the northeast quarter of section 8; the other on the Westcoat farm in the northwest quarter of section 22. Further, a dry hole was drilled in Benton township, Hocking county, just north of the pool under consideration. These failures pretty thoroughly surround the producing territory and leave little hope for an important extension.

The production of oil in the early summer of 1902 was 125 barrels per day, only four wells having been completed at that time. In September of the same year the five wells yielded 109 barrels per day. The initial production of the wells ranged from about 10 to 70 barrels each per day. All flowed at first, but with one exception had soon to be pumped. The gas well is reported to have had an initial rock pressure of 650 pounds per square inch, and an open flow of 750,000 cubic feet per 24 hours.

A log of the McNichols well has already been given in the chapter treating of the Central Ohio Natural Gas Fields. One additional record will be given. This is the M. J. Hill well No. 3:

		Feet.
Drive pipe (8 inch)		18
Casing 6⅝ inches	760 feet	
Top of Corniferous limestone		1,570
Bottom of Niagara limestone		2,270
Casing 5 13-16 inches	2,413 feet	
Top of Clinton sand		2,428
Bottom of Clinton sand		2,443
Total depth		2,449
Tubing, 2 inch	2,449 feet	

The sand differs much in color from that found in the Sugar Grove and Homer fields, being much darker. In fact it sometimes becomes red-brown.

The success of these wells produced considerable interest among oil men, and large areas were leased in this and adjoining townships. The prevailing rental has been 50 cents an acre per year.

Knox Township.—This lies along the eastern line of the county. A number of wells have been drilled in it, especially on sections 22 and 23. The objective formation in these has been the Berea grit, and a small production of oil has been secured. Results thus far do not indicate that anything of marked value will result from these wells.

Swan Township.—In 1901 a well was drilled on the Cradlebaugh farm about one mile south of the station, Orland. The Clinton sand, which was found at a depth of about 2,900 feet, began flowing gas at about the rate of 400,000 cubic feet per day, the closed or rock pressure having been 690 pounds per square inch. Encouraged by this result a second well was drilled the following year on land of Robert Wadsworth, about one-half

mile north of the Cradlebaugh well. The Clinton sand in good quality was found at 2,811 feet, but was entirely dry. Both wells were drilled by the Ohio Oil Company.

GALLIA COUNTY.

The search for oil in this county began at an early day. In the spring of 1861 a well was begun on section 30, Addison township. It had reached a depth of 150 feet when the Civil War began, and drilling at once ceased, the workmen enlisting in support of their country. No further work was done until the war closed, and the well begun in 1861 was never finished.

The first complete oil well ever drilled in the county was in 1865 on land of John Martindale in section 30, Addison township. The well was about 74 feet deep, and during 40 days produced perhaps 12 barrels of oil per day. The oil was thick and heavy, and was sold for lubricating purposes. The company's receipts show that about 500 barrels were sold. After having pumped the well for 40 days with the results as reported, eastern parties visited the field and persuaded the owners that if they would drill deeper a flowing well would be secured. The advice was heeded, but the results promised did not follow, and what was worse the old well was ruined. During several years following a number of wells were drilled in the neighborhood, and all produced oil, but not in paying quantities. In 1898 nine wells were drilled on farms belonging to John Martindale, Enos George, Owen Thomas and E. M. Fulton, and oil was found in all with a single exception, but not in paying quantities.

In 1865 a well was drilled at Adamsville on the east side of Raccoon township along the east bank of the creek of the same name. The total depth of the well was about 800 feet, and the rock was there unproductive. At 400 feet considerable gas was found, and it is said to be escaping at the present time. Quite recently a well has been drilled in the southeast corner of Raccoon township. A show of oil was secured in the Berea, but the drill liberated a flood of salt-water and the well was a failure. The following log of this well, and the information relating to the county were kindly furnished the Survey by Mr. J. W. Jones:

	Depth of stratum. Feet.	Total depth. Feet.
Surface material	26	26
Sandstone	42	68
Slate, Coal No. 6 A and clay	5	73
Sandstone	26	99
Shale	13	112
Middle Kittanning coal No. 6	7	119
Clay and slate	67	186
Coarse sandstone	7	193

	Depth of stratum. Feet.	Total depth. Feet.
Ferriferous limestone	7	200
Coarse sandstone	25	225
Sandy shale	23	248
Sandstone	42	290
Slate	39	329
Sandy shales	74	403
Coarse sandstone	42	445
Black slate	55	500
Limestone and slate	70	570
Sandstone	16	586
Coal (No. 1?)	1	587
Sandstone, Salt-sand	506	1,093
Shale	31	1,124
Sandstone	41	1,165
Cuyahoga shales	145	1,310
Berea shale (Black)	20	1,330
Berea grit	15	1,345
Blue shales	8	1,353
Red shale (Bedford)	60	1,413
Ohio shale	4	1,417

The Salt sand in this record is very unusual. It doubtless includes everything from the top of that formation to near the base of the Big Injun.

Mr. Jones has run the Y level from the surface of the well to the summit of the adjacent hills with the following results:

	Feet.	Feet.
Upper Cambridge limestone (top of hill)	2	2
Red clay	7	9
Hard sandstone	2	11
Shale	21	32
Lower Cambridge limestone	3	35
Slate	15	50
Red shale	5	55
Slate and shales	26	81
Sandstone	28	109
Slate	15	124
Coal No. 7 (U. Freeport)	2	126
Clay	2	128
Slate	18	146
Red shale	4	150

On the Betz farm in Addison township a well was begun in the year 1889 probably. It was located by a forked stick and the "smeller" reported the producing territory 23¾ yards long, 9¾ yards wide, and of unknown depth. It was expected that oil would be found at a depth of 500 feet, and the company lacked funds to push the work further. Pro-

gress was very slow. At one time nothing was done during 4 years, and not until about 1898 was the Berea struck. The production of oil was from 1½ to 2 barrels per day before shooting, and less afterwards.

A Berea well was drilled on the William Boice farm adjoining the Betz in 1899. It made a showing of oil, but was never shot. About one mile west from the Betz farm a Berea well was drilled in 1899 on the Cole property. It never made more than a showing of oil, but produced considerable gas. About one-fourth of a mile south of the Betz, a Berea well was drilled on the Swisher farm. It produced about 2 barrels per day. In August, 1900, a well drilled near the center of section 34, Addison township, struck the Berea at 1,503 feet. The rock was fine grained and had a thickness of 11 feet. It contained some gas and produced one-half barrel of oil per day.

In 1887 a deep well was drilled on the land of John E. Mills, near Mills Station, by the Gallipolis Natural Gas Company. A heavy oil is reported to have been found in a 4 foot seam of coal at a depth of 325 feet. A 7 foot seam is reported at a depth of 578 feet. It should be borne in mind, however, that such data in so far as it refers to coal beds is very unreliable. The drillings of the reported seam are reduced to mud, and a soft dark shale when ground up in this manner may be readily taken for coal. Besides the measurements may be incorrect. A heavy string of tools, such as is used in deep wells, passes through coal seams so rapidly that the driller is liable to err in his measurements. Especially is this true when the steel measuring line is not used, which is commonly the case. Veins of brine were found at 678, 730, 930, 1,213 and 1,475 feet. The Berea was struck at 1,475 feet and was 32 feet thick, but contained nothing more than salt-water. From a shelly sandstone, 3 feet in thickness which was struck at a depth of 2,458 feet, one barrel of lubricating oil was secured. The Corniferous limestone was reached at 2,865 feet and the drill was forced on to a depth of 2,910 feet, when the tools became fast and the well was abandoned. A log of this well may be found in the Pennsylvania Second Geological Survey, Vol. XV., page 335.

A deep well was begun May 14, 1896, on Keton's run in Huntington township. It passed through 15 feet of Berea sand and reached a total depth of 1,765 feet, but nothing was secured to compensate the operator for his time and money.

The production of oil and gas in the county, it will be seen from what has just been said, is comparable to that in Athens county. That found up to the present time has been insignificant in comparison to the money expended. In fact the yield has been sufficient merely to lead the operator on and on in hope of finding a large pool. The outlook for a good production of either oil or gas in this county is not promising.

MEIGS COUNTY.

The existence of oil and gas in this county was discovered in drilling for salt. Somewhere between 1830 and 1840 a well drilled for that product near the mouth of Leading creek in Rutland township, found some oil and gas. The first well in Meigs county that ever produced oil to any commercial extent was drilled about 1852 in Pomeroy near the line separating that city from Middleport. The well was drilled for salt, but at a depth somewhere between 200 and 400 feet oil was found. It flowed into a ravine and then into the river. Finally, lest the oil might set fire to the boats, a dam was built in the ravine. Nearly 100 barrels of this oil were shipped to St. Louis where it was sold as a liniment.

Somewhere between 1855 and 1865 a well was drilled about 1¼ miles northwest from Rutland in Rutland township. At a depth of 830 feet a dark lubricating oil was found. The surface of the well is reported at about 50 feet below the Pomeroy coal (No. 8) seam. The well is still producing but in quantities so small that the oil is not saved. Between 1880 and 1885 a well was drilled a few yards from the last one on the Rightmire farm. Oil was found in small quantities at about the same depth as in the neighboring well, but drilling did not cease until a depth of 1,971 feet was reached. No valuable deposits were found. Later another well was drilled in the same vicinity by farmers. Without being shot, oil and water were thrown to the top of the derrick, but the operators quarreled and the well was abandoned. A short distance southwest of these wells another one was drilled about 1890 on the Savage farm along the border of Salem township. Oil was found, but the operators ran out of funds and the well was abandoned.

Near Minersville several wells were drilled for salt. At a depth of about 475 feet oil or gas was found. From one the oil flowed so freely that it ran into the river. The oil and gas were shut out by casing, however, and the wells used for salt.

In the early sixties Thomas fork, which lies about 1½ miles back from Pomeroy, was a small oil field. Between 15 and 20 wells were drilled, some as deep as 300 feet, but the greater number were less than 150 feet. Several hundred barrels of oil were shipped from the Highland well to Marietta. Drilling is still being done in this locality.

In 1894 a well was drilled to a depth of 1,780 feet on the Carr farm along the eastern line of Salisbury township. Some gas and a small show of oil were found, but the well was abandoned. North of Enterprise, in the same township, a well was drilled for oil in the sixties. Considerable gas but no oil is said to have been found.

About 1894 a well was drilled to a depth of 2,500 feet on the Devlin farm in Olive township. It made a showing of both oil and gas, but the well was abandoned. This territory is now (1900) leased by the Carter Oil Company.

More than 15 years ago Oscar Chase drilled a well on his farm in Rutland township. The drill reached a depth of perhaps 1,000 feet. Only a showing of oil was found, but there was sufficient gas to heat and light his residence.

Several wells have been drilled to a depth of about 1,000 feet near New Lima. All made a showing of oil, but beyond this there was nothing to reward the operator.

KNOX COUNTY.

In 1884 a deep well was drilled on the bank of Owl creek south of the Baltimore and Ohio station, Mt. Vernon. The Berea sand was struck at a depth of 478 feet and was 30 feet in thickness, but contained salt water only. The drill was kept at work until the underlying Bedford and Ohio shales were drilled through, and the Devonian limestone penetrated to a depth of 78 feet, when an accident occurred and the well was abandoned. A thickness of 1,000 feet was reported for the Ohio shales, but from a record shown on a later page this appears too large. At the bottom of the drift, which was 87 feet thick, a heavy flow of fresh-water was secured, and this now furnishes part of the city's supply.

This failure, however, did not convince those interested that the territory was lacking oil and gas in commercial quantities, and arrangements were made to continue the exploration. About two years later a well was drilled on the farm of Thomas Banning, two miles north of the city limits. The depth reached is reported to have been nearly 2,000 feet. A light flow of shale gas was the only reward for the heavy expenditure of labor and money. In the same year a well is reported to have been drilled on land of George Simpkins 4 miles northeast of the city. The depth was about 200 feet less than in the Banning well, but the results were similar. In the spring of 1887 a well was drilled near the city limits. The Berea 20 feet thick, was struck at a depth of 453 feet, and 887 feet below the Berea the Corniferous limestone was found. Work continued until the Lower Helderberg and Niagara limestones had been passed through. The total depth of the well was at least 2,600 feet.[1] About this time the city of Mt. Vernon, acting under authority of the legislature, provided $10,000 to continue the investigation. The objective stratum was the Clinton, since it had already been shown to contain valuable reservoirs of gas at Lancaster, Thurston and Newark. Two contracts provided that a depth of 3,500 feet should be reached, with the hope of finding the Trenton which had shown such unexpected results in Northwestern Ohio. The first of these wells was completed in the fall of 1889, and because of the light that it throws on the thickness of several members of the Ohio Geological column, the following record taken from Dr. Orton's report is here given in full.[2]

[1] *Geol. Sur. of Ohio, Vol. VI., p. 367.*

[2] *Geol. Sur. of Ohio, First Ann. Rep.* (1890), p. 244.

	Feet.
Drift	244
Cuyahoga and Berea shales	173
Berea grit, carrying salt water	38
Bedford and Ohio shales	705
Corniferous and Upper Silurian limestones	895
Niagara shales	90
Clinton reached at	2,125
Red rock	18
Shale and sand	20
Red rock	50
Hard sand	15
Medina shales at	2,275
Hudson River shales at	2,475
Well finished probably in Utica shale	3,200

The shales called Niagara probably form part of the Clinton series. This will be made clear by examining the well records in the chapter devoted to the Clinton rock natural gas fields.

The lower formations were barren, but the Lower Helderberg limestones contained much salt-water. The only valuable product was gas in the Ohio shales. The rock pressure of this was 185 pounds and the daily production 78,000 cubic feet. This fuel was used under the boilers of the waterworks. Three or four years later a well was drilled on the farm of Samuel Ewalt, one mile west of the city. This is reported to have reached a depth exceeding 3,000 feet with results similar to those of the preceding one. In 1901 two wells were drilled near the city waterworks with the hope of securing fuel for its boilers. The depth reached was about 900 feet, and a small supply of gas was found.

Within the past few years a number of wells have been drilled in the valley of the Kokosing in the eastern part of the county. The first of these, located on land of E. and A. Rightmire, drilled in 1899, found the Berea at 575 feet. This sand made a show of gas, and drilling continued about 400 feet deeper in the Bedford and Ohio shales, but these were dry. Six wells have been sunk on the Stricker farm in the same neighborhood. The Berea was drilled through and produced sufficient oil to warrant pumping. This was found unprofitable, however, and in less than a year the wells were abandoned. A well or two have also been drilled on the Smethe farm in the same locality, with results similar to those on the adjacent farms. About 1899 Peter Neff drilled several wells in the vicinity of his old lamp-black factory, but these were failures.[1]

In 1900-1 a number of wells were drilled in Union and Butler townships. Twelve were on the John Hammond farm, three only of which were producing in September, 1901. When first drilled these made from 100,000 to 500,000 cubic feet of gas per day, but the decline has been rapid. On the Butler, Buffington and Welker farms which are in the same neigh-

[1]*See page* 291.

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borhood as the Hammond, a half dozen wells have been drilled with results similar to those just mentioned. In this field the Berea, which is the producing sand, varies from 5 to 60 feet in thickness. Gas is found in the top of the sand and salt-water below. When the latter is liberated the well is ruined.

In the vicinity of the village Howard, in the township of the same name, several wells have been drilled. The first two of these date back perhaps 15 years and data are meager concerning them. It is known, however, that they were never pumped. Two or three years ago a well was drilled near the C. A. & C. R. R. station. The Berea, 15 feet thick, was struck at 527 feet. Some oil was found, and the well was pumped for a brief period. Three additional wells were drilled near the village with similar results.

From what has been said it is apparent that the results accomplished have not been in keeping with the time and money expended. In fact, if the story closed here the county could not be ranked among the producers of either oil or gas. Within the past three years, however, an important gas field has been developed in the southern part of the county, including parts of Miller, Milford and Morgan townships. This forms an important part of the Homer field. Apparently the limits of this territory have not yet been demonstrated, and further drilling may extend it, especially to the east. Since this gas territory has already been discussed, no further consideration will be given it here.[2]

WAYNE COUNTY.

About the year 1885 a test well was drilled within the corporation of Wooster. The Berea was found at 590 feet and was 65 feet thick. Work continued until a depth of 2,000 feet was reached and then the well was abandoned. It was a total failure. Not convinced by this result an old company, known as the Wooster City Milling Association, which had been dormant for 15 years, was revived and two wells drilled just west of the city. A record of one of these was as follows:[1]

	Thickness of formation. Feet.	Total depth. Feet.
Drift	28	28
Sandstone and shales	207	235
Shales with thin beds of sand	215	450
Berea grit	15	465
Bedford shales, red	108	573
Ohio shales	1,232	1,805
Devonian limestone at		1,805

Neither of these wells made more than a showing of gas. These failures carried conviction and no further testing was done until 1900 when a well was sunk on the Branstetter farm along the Wooster corporation

1*Geol. Sur. of Ohio, Vol. VI., p.* 362.
2*See page* 116.

line. This found the Berea at 465 feet and made a showing of oil, but the well was abandoned without reaching the base of this formation. In the same year a well was drilled on the Bell farm one mile south of the city. The Berea was found at 450 feet, and the Devonian limestone at 1,918. Work ceased at a depth of 1,957 feet, but the operator hoped to take up the task again with the Clinton formation as the objective stratum. In the spring of 1900 a well was drilled on the Smyser farm near Overton. The Berea was penetrated to a depth of 65 feet and then the well was abandoned, owing to the heavy flood of salt-water encountered. About the same time a well was drilled on the Jones farm three miles south of the village with results similar to those just reported.

In December, 1900, the "Dalton Oil, Gas and Mineral Company" was incorporated with a capital stock of $10,000. The object was to test for oil, gas and other mineral products having an economic value. The first well drilled in the valley of Sugar creek in the summer of 1901, found the Berea sand at 629 feet. The formation was divided as follows:

	Feet.
Sand	35
Shale	10
Sand	30

The well was a failure. The second well was located within the corporation of Dalton, and about two miles east of No. 1. According to F. F. H. Pope, M. D., to whom the Survey is indebted for information concerning this territory, the Berea sand is found 9 feet higher in this well than in the preceding one, indicating the existence of an anticline. In the upper division of the Berea a good showing of oil was found, but when the lower stratum was tapped a heavy flow of brine was liberated and this ruined the well. Work continued to a depth of 1,500 feet with the hope of finding the Gordon or one of the deeper sands, but this was a failure. Subsequently the Berea sand was shot with 80 quarts of nitro-glycerine, but this left the well in such condition that the operators were unable to pump it, and the well was plugged and abandoned. Well No. 3 was drilled about one-half mile farther east and found the Berea at 720 feet. This was 11 feet lower with reference to sea level than well No. 2. Seven feet of pay-rock were reported in the upper division and this was shot with 40 quarts of nitro-glycerine. The result was regarded fairly satisfactory, three barrels of oil having been bailed in less than two hours. At this stage the contractor moved his tools, and the well caving, the company was not able to keep it clean, so that this too was a financial failure.

HOLMES COUNTY.

This county has not been as thoroughly tested as some others, and yet a large amount of drilling has been done. Many of the wells have made a good showing of oil or gas, and occasionally a small producer has been

secured. All, however, have soon been abandoned, and practically nothing of a pecuniary value has been secured to reward the patient operator.

Richland Township.—Between 30 and 40 years ago a well is reported to have been drilled on the Sylvanus Purdy farm. The depth was not learned. It is said to have produced a little gas, but not sufficient for any use. About 1850 a well was drilled on the Stuber farm one mile west of Purdy's, but this too was a failure. No further work was done until 1899 when four wells were drilled. One was on the William Simmons farm a mile northeast of Glenmont. The Berea sand was found, but was dry. The next well was drilled on the Zoller land adjoining the village just named. The Berea sand, 7 feet thick, made a showing only of oil and gas, and so the well was abandoned. On the farm of Daniel Jones, situated two and one-half miles east of Glenmont a well was secured which made sufficient gas for a residence. Encouraged by this success a well was drilled on the Cornell farm adjoining the Jones, but this was a total failure. The records of these have not been secured, but in all probability work did not cease until the Berea sand was penetrated.

Washington Township.—Near the village of Nashville two wells have been drilled within the past two years, one on the McMillen and the other on the Knox farms. Both were failures.

Kilbuck Township.—About 35 years ago the Millersburg Oil and Gas Company drilled a well on the Quillen farm about two miles north of the village of Kilbuck. A depth approximating 1,000 feet was reached, but a showing only of oil and gas was secured. In 1899 a well was drilled on the Duncan farm adjoining the village just named. One hundred and ninety-eight feet of drive pipe were reported, and the Berea, 20 feet thick, was found at 642 feet. The well produced at first 5 barrels of oil per day, but the production was not maintained and pumping soon ceased. A year later a well was drilled on the Carpenter farm just east of the village. The Berea was found at 662 feet and the results were similar to those in the Duncan well. Two additional wells were drilled in the same locality in 1900. In both the Berea made a small quantity of oil, but not sufficient to warrant pumping. This territory barely missed being a small producer. With this encouragement the rocks were tested further from the village. On the Carpenter farm one mile southeast the Berea made a showing similar to the wells previously reported. A test was next made on the Lane farm one-half mile northeast of the village, but the Berea did not make as good showing as the wells at Kilbuck. In September, 1900, a well was drilled on the Christopher farm, adjoining the Lane. The sand made a showing of oil but produced considerable salt water. A well on the Stout farm one mile south of Kilbuck found the Berea at 626 feet. It made a show of both oil and gas. The drill was next moved west of the village, with the hope of better results. The well

was located on the Beller farm, and found the Berea at about 628 feet. It made a show of oil and sufficient gas for the farmer's residence. In the spring of 1901 a well was drilled on the Schneberger farm two miles southeast of Kilbuck. It made a little oil and with it some salt-water. With the exception of the Christopher well all were torpedoed with from 20 to 60 quarts of nitro-glycerine.

Hardy Township.—In 1886 a test well was drilled at Millersburg. A record of this furnished by Strome and Hull is as follows:

	Thickness of stratum. Feet.	Total depth. Feet.
Clay and rock	40	40
Blue sandstone	60	100
Slate	20	120
Conglomerate	8	128
Blue stone, soft	22	150
Rock	10	160
Blue rock	25	185
Slate	20	205
Solid rock	25	230
Slate	10	240
Solid rock	40	280
Slate, light and dark	445	725
Berea sand, blue	20	745
Slate, dark	140	885
Solid rock	10	895
Light slate	470	1,365
Dark and light slate	330	1,695
Sand rock	5	1,700
Light slate	10	1,710
Dark brown slate with limestone shell	70	1,780
Dark and light slate	320	2,100

The Berea made a showing of oil and gas, and was reported free from salt-water. The drill was moved to the Netherow farm 4 miles from Millersburg. This well produced some lubricating oil and has been pumped irregularly since that time. It makes gas enough also to heat and light the farmer's residence. Two additional wells were drilled in the same vicinity, but the results were less favorable.

TUSCARAWAS COUNTY.

More than 30 years ago a well was drilled on the Waddington farm about two miles north of New Philadelphia. This was the first attempt to secure oil in the county. The depth of the well was not learned. No oil was found, but the rock was charged with salt-water, and the company decided to make use of this. Accordingly a plant was erected, and from 60 to 65 barrels of salt per day are said to have been made from this well. Later other wells were drilled in the same vicinity and the locality became

for a time a salt producer of some importance. The shales above the Berea are reported to contain some gas, and an operator of experience has expressed the opinion that small but profitable wells might be secured in this.

In 1884 a well attaining a depth of 2,760 feet was drilled at Canal Dover. The record of this is given below:[1]

	Feet.
Lower Coal Measures	235
Logan group	195
Cuyahoga shale	419
Berea shale (black)	11
Berea grit	26
Bedford and Ohio shales	1,874

The well head was at the horizon of the Lower Mercer limestone. The Berea contained a little gas and considerable salt-water. About the same time a Berea well was drilled along the canal about two miles south of New Philadelphia on land of Daniel Corns. Considerable salt-water but neither oil nor gas was secured. The prevalence of brine in this part of the county shows that the rocks lie quite flat, or in other words that the relief necessary for the accumulation of oil and gas is wanting.

Warren Township—Several wells have recently been drilled near Cumberland. All are reported to have reached the Berea sand, but made nothing better than a show of oil and gas.

Oxford Township—Two wells have been drilled near Post Boy, one some years ago and the other within the past year. Both went through the Berea grit, and the last one 200 feet perhaps into the underlying shales. Each made a showing of oil and gas.

Washington Township.—Several wells have been drilled near the village of Gilmore. The first one was on the Lanning farm and was sunk about 12 years ago. The Berea, which was found at about 1,200 feet, contained some heavy oil which was bailed from the well for a time and used as a lubricator. A small quantity of gas still flows from the well, but no use has ever been made of it. In 1889 a well was drilled by the Port Washington Oil and Gas Company two and one-half miles southwest of the village on the Murphy farm. The Berea was reported absent, and hence nothing was secured. In the following year a well was drilled on the Kail farm one and one-half miles east of Gilmore. The Berea here made a showing of oil and with it considerable salt-water. In the winter of 1900-01 a well was drilled on the Parker farm one mile northeast of the village. The Berea was found but contained a show only of oil.

Salem Township.—Early in 1899 the Port Washington Oil and Gas Company was incorporated with a capital stock of $6,000. The object was to test the rocks in that locality with the hope of finding a large supply of oil or gas. The first well was located on the Brenner farm, and was begun May 5th. The record of this was as follows:

[1] *Geol. Sur. of Ohio, Vol. VI., p.* 369.

	Feet.
Clay and mud	85
Salt sand	237-275
Big Injun sand	320-483
Berea grit	868-947
Shales	947-1509

The reported thickness of the Berea is unusually large. It contained a little oil and gas, the latter making a flame 8 feet high. No use was made of either product, owing to the small quantity, and the well was abandoned.

The second well was begun June 1, 1899, and was located on the Welsch farm one mile southeast of the village. The Berea was found at a depth of 1,013 feet and was 92 feet thick. The sand produced a heavy flow of salt-water which the drillers were unable to control. The third well was drilled on the Murphy farm in Washington township, and may be found recorded there. Well No. 4 was located on the Stocker farm about three-fourths of a mile northwest of Port Washington. The Berea was reported from 10 to 12 feet only in thickness, and made a small showing of gas. The fifth and last well drilled by the company was located on the Welsch farm, a few hundred feet from the other well on that place. The first well was reported to have produced some gas in a shallow sand, and the second well was drilled to that formation, but it contained neither oil nor gas.

Warwick Township.—In 1900 a well was drilled on the Anderson farm one and one-half miles west of Tuscarawas. The sand made a show only of oil.

Lawrence Township.—Within the past few years a number of wells have been drilled near Zoar. No records of these have been placed at the disposal of the Survey. All, however, were failures.

Mill Township.—A number of wells have been drilled in this township largely with the hope of finding a supply of gas for the manufacturing establishments of Dennison and Uhrichsville. About 10 years ago a well was drilled on the Carmack land near the last named town. No record of this has been secured, but the Berea sand is reported to have been found and made a show only of oil and gas. About 1896 a well was drilled on the Arthur farm near Dennison. The Berea is reported to have been passed through, and to have made a small show of gas. The depth of the well was approximately 1,400 feet. In 1899 a well was drilled on the Brown farm one-half mile north of Urichsville. The Berea sand, 40 feet thick, contained some oil and gas, but such a flood of brine was liberated that it ran from the top of the well. Encouraged by this well another one was drilled on the same farm, but the results simply duplicated those already given. Three wells have been drilled near the village of Newport. These were located on the Paul, Hines and Westhafer farms. Those on the last two farms were dry, but those on the Paul land produced a few barrels of heavy oil. All are reported to have reached the Berea sand.

COSHOCTON COUNTY.

Exploration for oil and gas in this county began in 1865. In the northwestern part of the county and the adjacent part of Knox, principally in the angle made by the junction of the Mohican and Kokosing rivers, more than a dozen wells have been drilled. Gas springs were early observed in this territory, and with this encouragement a company was organized to test the rocks. The first well was drilled in 1865 on the south bank of the Kokosing river in New Castle township, Coshocton county. At a depth approximating 600 feet a very heavy flow of gas was found. The well was left open a number of years and a great quantity of fuel was accordingly wasted. Twenty-two years later the production was measured by Dr. Orton and was found to be nearly 70,000 cubic feet per day.[1] Another well was drilled the same year just across the river from the first one. It too produced much gas. During 9 years this was allowed to escape, and then the well was properly cased and packed. In 1887 it was producing nearly 165,000 cubic feet per day. Within the ensuing 12 years 6 additional wells were drilled. In nearly every one of these oil and gas with salt-water were found, but none equalled Nos. 1 and 2 in their production of gas. The cost of this exploration is said to have been about $85,000. Other wells have been sunk since that time, two of which drilled between 1880-1888 were good producers. Within the past few years Peter Neff drilled several wells in the same territory, but these were all failures. The old wells were put to an unique use, viz.: the manufacture of lamp-black, and for a time this was the only plant in existence in which natural gas was used for this purpose. The early history of this industry has already been given, and will not be repeated here.[2] Tests have been made in other parts of the county, and these will next be briefly reviewed.

Tuscarawas Township.—A well is reported to have been drilled many years ago in the village of Roscoe, and a little oil and gas found. Neither was ever used, however, owing to the small quantity. In 1886 a deep well was drilled in the valley at Coshocton. The drift was 171 feet deep, and the Berea was found at 860 feet. It contained a little oil with salt-water. Not satisfied with this, work continued until the Ohio shales had been penetrated several hundred feet, but without success. Near the same time a well drilled on the Crawford farm one mile southwest of Roscoe, where nothing but salt-water was found. About 10 years later a well was drilled on the Haight farm one mile northwest of Roscoe. The Berea was drilled through, but made a show only of oil. In 1899 a well was drilled on land owned by John Hall. The Berea made nothing better than a show of oil. About the same time two additional wells were drilled in that locality,—one on the Gross farm which made a show of oil,

1*Geol. Sur. of Ohio, Vol. VI., p.* 342.
2*Ibid, Vol. III., p.* 340, *and Vol. VI., p.* 340.

and the other on the Stockum land. The latter produced some oil and was still being pumped in August, 1901. Encouraged by this success another well was being drilled on the same farm at the time mentioned. These wells went to the Berea sand.

Lafayette Township.—Five wells have been drilled in this township within the last three years. All reached the Berea sand. The wells are as follows: One on the Noble farm 3 miles east of the Court House. This made sufficient oil to warrant pumping a short time. One on the McGuire land, drilled in 1901, was dry. One on the Burt farm made some gas, but not sufficient to be of financial importance. The well on the Wiggins farm made a show of oil.

Adams Township.—Three wells have been drilled on the Corbett farm in sections 18 and 19. The total depth reported is 1,800 feet, the Berea having been found at about 800. This well is said to have been started many years ago and to have been completed about 1886. The second well was drilled not long after. When a depth of 600 feet was reached the operators became involved in litigation, and the well was abandoned. The third well on this farm was drilled 5 or 6 years ago, and is said to have gone over 1,000 feet below the Berea. It too, was a failure, the Berea being dry, though a showing of oil was found in the shales below. Within the past two years four wells have been drilled near Bakersville P. O. Two were on the Ott farm, and two on the Fiatt. All reached the Berea sand, but all were failures.

White Eyes Township.—One well was reported in this township. It was located on the Kobel farm in lot 5, about one mile west of Avondale. The Berea sand was found dry.

Linton Township.—Two or three years ago a well was drilled in this township, probably on section 7. The Berea was found but was dry.

Franklin Township.—About 1898 a well was drilled in on the Lapp farm in section 18, but the Berea here as almost everywhere else in the county was dry.

Jefferson Township.—Several years ago a well was drilled just north of Warsaw, but the Berea sand was dry. Not satisfied with this a well was drilled on the south side of the village, but with results similar to those of the preceding well. On the Hawthorne farm near the west line of the township and close to the Walhonding river a Berea well has been drilled. This must be added to the long list of failures already recorded.

CARROLL COUNTY.

A persistent search in this county has been made for oil and gas. Everywhere the objective stratum has been the Berea sand. Frequently this has shown oil and gas but not in commercial quantities. With these products there has usually been found salt-water. The rocks of the county

appear to lack the arches or folds necessary for the gathering together of the oil or gas, and so while a small quantity of these may be found almost anywhere a large quantity exists nowhere.

Orange Township.—On the Clark farm in section 16 a Berea well is reported to have been drilled nearly 20 years ago. It made some gas, and this is said to be escaping at the present time. In the spring of 1900 a well was drilled on the Barrick farm near the west edge of Sherrodsville. The Berea was found at about 900 feet, and contained some gas. With it, however, was salt-water, and the well was abandoned. During the following summer a Berea well was drilled on the Roby farm just north of town (Monroe township), the results being similar to those in the Barrick well. A dry hole has been drilled on the Gartell land in section 36, and one on the Holmes tract in section 35. On section 22 in the extreme southeast corner of the township, no less than 5 wells have been drilled. Of these one located on the Boreland tract made sufficient promise to warrant pumping a short time. The production, however, was not maintained and the well was abandoned. The other wells were dry.

Brown Township.—About 1899 a well was drilled on the Cunningham farm in the northwest quarter of section 13. The Berea contained sufficient oil to warrant pumping, but the production did not meet expectations and the well was abandoned. In the fall of the same year a well was drilled on the Tillett farm. A good show of oil was found, but it was overwhelmed by a strong flood of brine.

Augusta Township.—A well reaching a depth approximating 1,500 feet was drilled on the Manfull farm in 1899. It was entirely dry. Two years later a well was drilled on the Moncrief land in section 35. This made a show only of gas. Early in 1900 a well was drilled on the Wathey farm in the southeast corner of section 34. The Berea was found at 864 feet and was 54 feet thick. It was divided by a bed of shale, the lower portion being known as the "stray." After having been shot the well made a good show of oil, but trouble occurred in the company and the well was abandoned. A dry hole was drilled near this well on a small lot in section 35.

Washington Township.—In the spring of 1900 a Berea well was drilled on the Hewett farm in section 18. The Big Injun sand contained considerable salt-water, but the Berea was dry. A well has been drilled on the Carr farm, but at a depth of about 800 feet the tools became fast and the well was abandoned. About three years ago (1898) a Berea well, which was dry, was drilled on the Rowland farm in section 4. A dry hole has been drilled in the northwest corner of section 19.

Rose Township.—On the old Wadsworth farm near Magnolia a well is reported to have been drilled many years ago. It was never pumped, but the farmers skimmed the oil from the top of the well and used it in

greasing machinery. Recently a well was drilled near this one, but the Berea made nothing better than a show of oil.

Center Township.—In 1899 a well was drilled on the Lotz farm. The Big Injun sand contained much salt-water, and the Berea made a smell of oil. In the same year a well was drilled on the Buck farm, but the Berea did not make even a show of oil.

Union Township.—About the year 1895 a well was drilled on the C. F. Brooks farm in section 6, the depth having been reported at 1,500 feet. No oil was found in the Berea, but a small quantity was secured in a shallow sand. On the J. H. Brooks farm in section 12 a well was drilled to the shallow sand just referred to, but nothing better than a small quantity of black oil was found. On the T. F. Brooks farm in section 5, a hole was drilled to the shallow sand, and a small quantity of dark oil secured. This was pumped a short time. In the spring of 1899 a well was drilled on the Gantz farm in section 6. The Berea sand was 56 feet thick, and after having been shot with 50 quarts of nitro-glycerine produced two barrels of oil per day. The well was soon abandoned. About the same time a Berea well was drilled on the John Fawcet farm. It made a show of oil, but was abandoned without having been shot. A well is reported to have been drilled to a depth of 2,000 feet on the John Sell farm in section 9 in search of the Gordon sand, but without success. A large quantity of salt-water was secured. In 1900 a Berea well aws drilled on the Kahl farm in section 3. The well was shot and made some oil, but was not pumped. Notwithstanding this long list of failures a well was being drilled on the J. G. Brooks farm in 1901.

Lee Township.—In 1899 a Berea well was drilled on the farm of T. R. Taylor in section 22. Considerable gas and a show of oil were secured in the Big Injun and a show of oil in the Berea also. The well was never shot. Other dry wells in the township are as follows: One on the J. and G. Nohle farm in section 3; one making a little oil on the McEntire farm in section 2; one on the McConnell farm in section 34; one on the B. Noble farm in section 26; one on the Allen land in section 28.

Loudon Township.—On the John Scarlett farm in section 20 a Berea well was drilled in 1900. The sand was of good quality and produced some oil. In the same year a well was drilled on the R. Gibson farm in section 32. The sand made the usual show of oil and gas, but the well was abandoned without having been shot. In 1901 a well was drilled on the T. A. Stenger farm in section 31, and produced considerable gas, but this well also was abandoned without having been shot. On the Long farm in section 19 four wells have been drilled, one only of which was dry. The Berea was found at from 1,100 to 1,200 feet, and was from 30 to 40 feet in thickness. The producing wells made from three to four barrels per day. There is no pipe line in the field, and in 1901 the wells were

quiet owing to the lack of market for the oil. Just across the line in Jefferson county several wells have been drilled. The field is known as the Amsterdam. From the dry holes already drilled it seems safe to say that the territory will not become important.

Fox Township.—About 10 years ago a well was drilled on the Queen farm in section 11. The Berea sand contained a small quantity of salt water, but neither oil nor gas. On land of Frank Cummings in section 33 a deep well was drilled a number of years ago. The Berea sand is reported to have been reached and to have made a show of oil. About the year 1896 a well was drilled on the Allison farm in section 33. The Berea sand is reported 60 feet thick. After having been shot the well made a showing only of oil. About 6 months later a well was drilled on land of T. G. Donaldson in the same section. The sand there was hard and dry. A dry hole has been drilled on the George farm in section 28.

Monroe Township.—A Berea well was drilled on the Dutenhaver farm in section 35 in 1899. The sand made a show of oil, but the well was abandoned without having been shot. Dry holes have been drilled on the Suter farm in section 11, and the Roby farm in section 8. In August, 1901, a well was being drilled on the Davis land in section 20.

Harrison Township.—But one deep well was reported in this township, and this was dry. The well was located on the Lotz farm in section 8.

Perry Township.—Two dry holes were reported in this township, one on the Palmer farm in section 6, and the other on the Scott farm in section 17.

SUMMIT COUNTY.

A large number of wells have been drilled in this county. Some stopped at the Berea, but others continued until the great limestone below had been penetrated. The earliest of these wells, located at Akron, found the Berea grit at 260 feet and the Corniferous limestone at 2,125, making the interval between the two 1,862 feet. Work continued until the limestone had been drilled to a depth of 335 feet. The well was a total failure as far as oil and gas were concerned.[1]

About 20 years ago several wells were drilled near Clinton in the southwestern corner of the county in search of a reported coal seam, but without success. The Berea grit was found, but was barren of oil or gas.

Within the last few years a number of deep wells have been drilled in the vicinity of Barberton in search of salt. Below is a record of well No. 1 of the Columbia Chemical Company, at Barberton:

[1] *Geol. Sur. of Ohio, Vol. VI., pp.* 357-9.

	Thickness of stratum. Feet.	Depth to bottom of stratum. Feet.
Sand, very soft	40	40
Gravel, very soft	20	60
Quick-sand	30	90
Slate, black, soft	45	135
Sand, black, soft	15	150
Cuyahoga and Sunbury (Berea) shales	310	460
Berea grit, dark	10	470
650 *feet of* 8¼ *inch casing.*		
Bedford and Ohio shales	1,710	2,180
Corniferous limestone top at		2,180
Lime, brown, very hard	60	2,240
Lime, gray, very hard	80	2,320
Lime, white	150	2,470
Lime, gray	30	2,500
Sand, brown, very hard	30	2,530
2,582 *feet of casing.*		
Lime	244	2,774
Rock salt	30	2,804
Lime	16	2,820
Rock salt	5	2,825
Lime	5	2,830
Rock salt	69	2,899
Lime	107	3,006

The wells usually make a show of gas at about 2,500 feet. This appears to be from the same horizon as the gas at Jefferson, Ashtabula county. These wells demonstrate that neither oil nor gas may be expected in the northern half of the county.

About 15 years ago a deep well was drilled near Peninsula in the northern part of the county. Gas was secured from the Ohio shales, and this is reported to have supplied a residence since that time. Later a half-dozen wells were drilled to the same horizon, with similar results. One well lighted the streets and about 10 residences for a short time, but the flow soon became inadequate. The best well now (1902) does not supply more than two residences.

A well having a depth of about 800 feet, was drilled in Northfield township in the northern part of the county in 1902. The Berea encouraged the operators, and they were planning a number of wells, hoping in this manner to secure a profitable supply.

STARK COUNTY.

As might be expected a county with such extensive manufacturing interests as Stark's would not rest content until a thorough test had been made of the underlying strata for natural gas. The result has been the discovery of two small reservoirs of the desired fuel, but the supply has not been at all in proportion to the energy and money expended.

In 1886 the Canton Steel Company drilled a well at Canton, reaching a depth of 2,200 feet, a record of which is given below:

	Thickness of formation. Feet.	Total depth. Feet.
Drift	17	17
Coal (No. 3 seam)	1	18
Slate and sandstone	43	61
Coal (No. 2 seam)	streak	61
Fire-clay, slate and sandstone	39	100
Sandstone	49	149
Slate	14	163
Coal (No. 1 seam)	streak	163
Fireclay and slate with thin beds of sand stone	112	275
Logan conglomerate (Big Injun)	140	415
Cuyahoga shale	260	675
Berea grit	80	755
Bedford shale, dark red	17	772
Total depth		2220
Ohio shale	1,448	2220

The elevation of the well head is about 1,030 feet above tide. At a depth of 110 feet so large a pool of water was found that it ran from the well. The Berea contained much salt-water, but neither oil nor gas. The base of the Ohio shales was not reached.

In 1887 another deep well was drilled in Canton. This was located near the intersection of Fourth street and East creek and was drilled by the Canton Oil, Gas and Coal Company. A large quantity of salt-water was found in a sand rock at a depth of 750 feet, and this formation was doubtless the Berea grit. The well was cased at a depth of 800 feet. From that point to a depth of 2,800 feet nothing but shales were found, and these were entirely dry. The total depth was reported at 3,250 feet. An unsuccessful effort was made to use a brine found at 2,800 feet for the manufacture of bromine.

In the fall and early winter of 1885 a deep well was drilled on the land of the Russell Manufacturing Company at Massillon. A record of this well has been furnished the Survey by an officer of that company, and is as follows:

	Thickness of stratum. Feet.	Total depth. Feet.
Sand and gravel	145	145
Conglomerate sand rock	40	185
Cuyahoga shale	425	610
Berea sand	45	655
Bedford flag rock	35	690
Ohio shales	1,825	2,515
Corniferous limestone	32	2,547

The Berea produced considerable gas, but it was soon overwhelmed by a flood of salt-water that flowed from the same stratum. Not long afterwards another well was drilled at the rolling mill in the northwest quarter of the town, but such a heavy flow of salt-water was found in the Berea that the well was abandoned. Other deep wells were drilled in or near the city years ago, but no specific data concerning them were secured. One thing, however, is certain, none were important producers of either oil or gas. In 1898 a Berea well making a show of oil was drilled on the land of H. H. Everhart about two miles west of Massillon. In 1900 a well was drilled on the land of George Snyder two and one-half miles east of Massillon. When the Berea sand was penetrated much salt-water was liberated, but there was no oil and but little gas. The well was not shot.

A number of deep wells have been drilled in Alliance and vicinity.[1] One is reported to have been drilled in the north part of town about 15 years ago and to have reached a depth of 2,800 feet, but it was dry. In 1900 a well, located on the Grove farm 5 miles east of Alliance, reached a depth of 1,500 feet, and so went far below the Berea, but it too was a failure. In the spring of 1900 a well was drilled on the Marchamb lot in Alliance, and reached the Berea at 640 feet. The rock was charged with gas, the closed pressure being 200 pounds per square inch, and the daily production 1,500,000 cubic feet. A well located 1,000 feet farther south was soon begun, and the rock pressure was similar to the preceding one, but the production was 2,500,000 cubic feet per day. The third well was located on the Bates lot lying 3,000 feet southeast of the last well. This produced 3,500,000 cubic feet per day. The largest well in the field was drilled late in the winter of 1900 on the Emery Miller lot, by the Morgan Engineering Company. It had a closed pressure of 200 pounds per square inch, and is reported to have produced at the rate of 5,000,000 cubic feet per day. In all about 20 wells have been drilled in this vicinity. These are very short lived, ordinarily not exceeding 3 months, and the best not lasting longer than 6 months. The great well of the Morgan Engineering Company lasted 3 months only. The wells are located along a northeast and southwest line. The producing sand in all cases is the Berea. In well No. 4 of the Transue and Williams Company, the formation was as follows:

	Feet.
Sand	44
Shale	4
Sand	86

The gas is found either in the bed of shale or in the top of the underlying sand. On drilling deeper a reservoir of salt-water is liberated. The field has been used very largely by the local manufactories, and in December, 1900, a line was laid through the town by the Eureka Oil and Gas

[1] *Data by Mr. O. F. Transue.*

Company, and families were supplied at the rate of 25 cents per thousand cubic feet. By August, 1901, the supply became so small that the demand could not be met.

Paris Township.—Four wells have been drilled in this township, one on the land of N. Stonehill and another on land of G. J. Geszner. Each made a showing of oil. One of these was drilled in 1897 and the other in 1901. In the latter year a well was drilled on the farm of Andrew Sponseller located one mile north of Myers. The Berea was found at 745 feet and had a thickness of 52 feet. It made a faint showing of gas. In the spring of 1900 a well was drilled on the Metz farm in section 2, but work stopped with a shallow sand, called Big Injun, by the driller.

Osnaburg Township.—About the year 1899 a well was drilled on the Wolf farm near Robertsville. The Berea sand was found at 680 feet, and after having been shot with 70 quarts of nitro-glycerine, made a very light flow of gas. The well was abandoned.

Washington Township.—In December, 1900, a well was drilled on the Hawkins farm in section 36. The Big Injun was reported at 420 feet, and contained much gas, but the well was ruined by salt-water. On the Miller farm, joining the Hawkins, a Berea well was drilled. The sand was reported at about 800 feet, but was dry.

Nimishillen Township.—Nearly 10 years ago a well was drilled at Lewisville, and reached a depth reported at 825 feet. A small flow of gas was found but was soon drowned by salt-water. In the summer of 1901 two wells were drilled on land of Henry Bixler in the extreme northwest corner of the township. The Berea sand having a thickness of 30 feet, was found at 660 feet. Each well produced gas, one having a closed pressure of 210 pounds and the other of 175.

Marlborough Township.—In the southwest corner of this township a few wells have been drilled. The territory is continuous to the Bixler property just mentioned. The Berea sand is about 30 feet thick, and the rock pressure 210 pounds. All the wells in this field were drilled by the Diamond Portland Cement Company which uses the fuel in its boilers and kilns. The company pays $200.00 per year to the land holder for each producing well.

MAHONING COUNTY.

Drilling in this county, while abundant to show the barrenness of the Berea grit and the underlying Ohio shales, has nevertheless been much less extensive than in the counties farther south. About 1866 or 1867 a well was drilled at Brier Hill, and reached a depth approximating 500 feet. Gas and oil were found at a reported depth of 420 feet, but not in paying quantities. The prominence of the iron industry at the county seat and the value of gas as a fuel in this business secured a more thorough test, and in 1875 a well was drilled to a depth of 2,480 feet at the Valley

Mill, Youngstown. The Berea grit was passed through at 200 feet, and from that depth to the bottom of the well the work was in shales and even then the base of the formation was not reached.[1] At Hazelton a few miles southeast of Youngstown, a well was drilled in 1886. In this gas was found in both the Berea sand and shales above, but the well was ruined by salt-water. The Berea grit attained a thickness of 160 feet in this well, a figure much in excess of other measurements in that part of the state. In the same year a well was drilled on the Reywight farm, 3 miles southwest of Youngstown. The Berea sand was found at 435 and had a thickness of 50 feet. Work did not cease until a depth of 2,075 feet was reached, but this did not find the base of the shales. Neither oil nor gas in commercial quantities was found.

In the summer of 1900 a well was drilled on the Creed farm a mile or less west of the corporate limits. The Berea was reported to have been found at a depth of 200 feet, and to have made a show of oil. Not until 300 feet of the shales underlying the Berea were passed through did work cease. In the same year a well having a depth of 600 feet was drilled near the village of Canfield, but made a show only of oil. In 1893 a well having a reported depth of 1,800 feet was drilled at Lowellsville, near the Pennsylvania line, but it produced neither oil nor gas. About the year 1894 several Berea wells, having a depth approximating 400 feet, were drilled near West Austintown, and yielded a small quantity of heavy oil which was bailed from the well for a short time.

TRUMBULL COUNTY.

This county ranks as one of the pioneer producers of oil in this country. In the spring of 1860 a well having a depth of about 60 feet was drilled at West Mecca. Oil was secured at 45 feet, and the production being considerable and the market small, a large supply soon accumulated. In the same spring two wells were drilled one mile south of the hamlet named; one, located on land of James Cowdery, is said to have produced 40 barrels per day, and to have been long lived though the production was at a diminishing rate. The second well was drilled on an adjoining farm and this too was a good producer. In both the pay-rock was found at about 50 feet. Another well was drilled in the same year on the Cowdery farm referred to above, but this one is reported to have been smaller, producing from 10 to 12 barrels per day. Besides, this well was short lived, having been abandoned about 1862. The wells on the Cowdery and adjacent farms were located because of so-called surface indications, consisting of a thin scum of oil on pools of water and occasionally on brooks.

The success of these wells attracted attention outside of the community and soon oil men in large numbers were drilling in the field. The production increased rapidly, and soon became a drug on the market. One

[1] *Geol. Sur. of Ohio, Vol. VI., p. 402.*

man hauled many barrels to Warren 12 miles distant, where it was finally sold for storage. Refineries were built that used not only the local production, but also some from Oil Creek, which was hauled in wagons. The refineries, however, were short lived and so played a small part in the history of the field. Work was brought practically to a standstill in 1861 by the opening of the civil war, many of the drillers abandoning their machines and entering the army.

Sometime between 1861-5 an attempt was made to secure the oil in an unique way; this consisted of shafts and tunnels. Three of the former were sunk, and when the Berea grit had been penetrated a few feet, tunneling began. To the east a small valley existed, and the plan was to extend the tunnel until it intersected the valley. Then it was expected that the oil would flow from the rock through the tunnel. The plan, however, was never completed. About 20 years later another attempt was made at tunnel construction. A shaft was sunk to a depth of 52 feet, and a tunnel was excavated from this 32 feet to the east and 30 to the west. After spending a small fortune in the foolish enterprise it was abandoned.

Soon after the close of the war work was renewed, and drilling became quite active. The neighboring townships of Mesopotamia, Bristol and Green were tested, the result being a few producing wells in each. The oil was a lubricator and most of it was shipped to Pittsburg, Cleveland and adjacent places. It commanded usually from 60 to 75 cents per gallon, but the price is reported to have risen to $1.25.

About the year 1878 active drilling in the field began for the third time, and tests were made in the surrounding townships, but the excitement lasted a few months only and then the drillers left the field. Much of the territory had been drilled before, and consequently the wells were small. Since that time an occasional well has been drilled. The Cowdery farm is still the best producer, but even here none of the wells are pumped regularly.

The early wells were drilled wholly by spring-pole. Instead of derricks three poles were set up. About 1870 steam began to be used, but the power was simply attached to the spring-pole. When drilling in the field began for the third time more modern methods were introduced. Derricks from 30 to 40 feet high were constructed, and the tools and power such as might have been found in other shallow territory at that time. By such methods a well could be drilled in two days of 12 hours each.

The oil is derived from the Berea grit which lies immediately below the glacial drift. At West Mecca the formation is 80 feet thick, and consists of beds of sand with an occasional intercalated bed of shale. Near Mecca two pay-rocks are found, one at 30 feet, and the other at about twice that depth. The lower sand is the larger producer, and the quality of oil is said to be similar in the two. The wells are not cased; the water being excluded by the primitive seed-bag, which served so useful a purpose in

the sixties. A number of wells were shot with gunpowder, but the results were not beneficial. The oil has a gravity of 26 degrees B., and bears an excellent name as a lubricator. It is safe to say that the life of the field is near the close. In fact the production during many years past has been so small that in a commercial way it might pass unnoticed. In the summer of 1901 the oil retailed at 40 cents per gallon, but considerable of a reduction was made when purchased by the barrel. No difficulty has been found in disposing of the product.

A number of deep wells are reported in the field; on the Foapes farm one mile east of West Mecca a well having a depth reported at 1,100 feet was drilled sometime between 1860 and 1870, and a flood of water, which still runs from the hole, was found. A well having a depth of 1,300 feet is said to have been drilled on the Cowdery farm about 1864; the deepest well in the territory was drilled on the Klump farm, three-fourths of a mile south of West Mecca, somewhere between 1880 and 1890, and reached a depth of 2,300 feet, but like the other deep wells just mentioned was a failure. In 1864 a well was drilled at Niles in the southern part of the county, and a heavy flow of gas was reported at 640 feet, but the drill was kept at work until a depth of 900 feet was reached, but the well was soon abandoned. Later another one was drilled in the same vicinity, but at a depth of 780 feet the tools became fast and work ceased.[1] In 1900-1 a well was drilled at Brookfield in the southeast corner of the county. It is reported to have reached a depth of 1,800 feet, but was dry.

ASHTABULA COUNTY.[2]

The Ohio shales, which everywhere underlie the county, and form the surface formation of nearly the whole of it, contain natural gas in large quantities, but unfortunately the product is so diffused that it cannot ordinarily be secured in commercial quantities. In other words the production of a comparatively large area is not confined in a small one, as in the well known oil and gas fields in other parts of the state. Many wells have been drilled in the county, especially in the northern part around the towns along the lake shore. At Conneaut, in the extreme northeastern corner, one reached a depth of 1,942 feet, passing through the shales and entering the underlying limestones, but a strong brine only was secured. Other wells drilled near the village yield some gas, but not enough to make the territory valuable. At North Kingsville a well reached a depth of 1,200 feet without finding the base of the shales. No gas was found below 372 feet, but small reservoirs were found at several horizons above that plane. A number of wells have been drilled at Ashtabula, and several have yielded a small supply of gas, each sufficient to meet the wants of a residence. The supply is derived from comparatively superficial depths, usually less than 500 feet. Several wells have been drilled in and around Geneva, in the

[1] *Geol. Sur. of Ohio, Vol VI., p. 401.*

[2] *This territory does not form part of the Carboniferous, but it is not sufficiently important to warrant a separate chapter.*

northwestern corner of the county with more than ordinary success. The gas has been found at depths ranging from 130 feet or less down to 1,400, and is used for fuel and light by those citizens fortunate enough to possess it.[1] Many of these wells were drilled 20 years ago, but more recently a number have been drilled in other parts of the county, and several have passed entirely through the shales into the great limestones below; one on the Hayes farm in Cherry township, drilled about 1897, is reported to have attained the great depth of 2,775 feet, but no information has been secured as to the strata passed through, and the depth given may not be correct. The well was a failure. In 1899 a well was drilled by the Jefferson Oil & Gas Company on a lot owned by J. A. Giddings, situated within the corporate limits of Jefferson. A record of this furnished by F. S. Jones, is as follows:

	Feet.
Black slate (Ohio shale)	1,810
Light colored limestone	288
"Gas sand," thin	
White sand, called "salt sand"	13
Gray rock	8
Black rock	8
Oil sand	13

This well produced 7 barrels of oil the first hour and then dropped suddenly to one and one-half barrels per day. Not long afterwards a well was drilled near this one with similar results. The oil has a gravity of 43 degrees B. These are the only oil wells secured thus far (1901) in the county.

In the spring of 1900 a well was drilled on land of George Hunter, two mile northwest of Jefferson. The base of the shale was found at 1,692 feet, and the "gas sand" at 1,989. The well yielded considerable gas, the closed pressure rising to 830 pounds per square inch. Since that time nine additional wells have been drilled in that locality, and all contained gas. According to F. S. Jones the closed pressure in these has is some cases exceeded 800 pounds per square inch. The daily production of the best wells has been about 2,500,000 cubic feet. As developed in 1901 the field has a length of three miles and a width of one. Its direction is northeast and southwest.

The sand has a thickness ranging from 30 to 40 feet. Gas is found in the very top, and just below lies a large reservoir of salt-water, which is constantly threatening the life of the wells. The Northeastern Oil and Gas Company has control of the territory, and supplies fuel to Jefferson, Ashtabula, Geneva and Conneaut.

In the fall of 1900 a well was drilled on the Traverse farm, two miles north of Jefferson, but a showing only of gas was secured. Outside of the localities mentioned a few deep wells have been drilled. One on the

[1] *Geol. Sur. of Ohio, Vol. VI., pp. 422-27.*

Strong farm in the southwest corner of Jefferson township reached a depth of 2,240 feet, but was dry. One on the Bancroft farm near Eagleville, found a heavy deposit of salt-water and so was abandoned. In the southern part of Plymouth township a well has been drilled on the Van Aken farm, but this was entirely dry.

A number of samples of drillings from below the Ohio shales have been provided the Survey for examination. These from the top of the Devonian limestone have a gray color and contain may fragments of fossils. A sample taken 25 feet lower had similar characters. Both effervesced freely with cold hydrochloric acid. The "gas sand" is composed almost wholly of quartz. It contains many fossil remains, especially Favosites or closely related forms. The "Salt sand" which lies immediately below has a light gray color. It consists of quartz with a little lime, the latter probably acting as a cement. The oil sand is much like the above.

From what has been said it is seen that the oil, gas, and salt rocks are sandstones lying about 300 feet below the base of the Ohio shales. This is the place of the Lower Helderberg limestone and the formation in question doubtless is of similar age. Similar beds of sand have been found in the Lower Helderberg in other parts of Ohio and adjacent states. Good examples are found at Monclova and Sylvania, in Lucas county, where the rock is of such quality that it has been used quite extensively in glass manufacture. Another good exposure is found in Wood county, where it is known as the Grand Rapids sandstone. Dr. Orton has expressed the opinion that the formation which is the source of the brines that supply the great salt works at Cleveland, Wadsworth and other points in the northeast corner of the state is probably the equivalent of the sandstones just mentioned.[1] Those of Ashtabula county occupy a similar position.

GEAUGA COUNTY.

The surface formation in this county belongs in part to the Coal Measures, in part to the Lower Carboniferous and in part to the Ohio shales. The Pottsville conglomerate is prominent, forming in places a conspicuous escarpment.

A number of deep wells have been drilled, but the records have become scattered or lost, and consequently it has been impossible to secure accurate data. In 1899 a well was drilled on the Kiser farm near Hampden. According to report a depth of 2,472 feet was reached; the Berea was found at 175 feet and the Corniferous limestone at 2,000. Nothing more than a show of oil was reported. In the summer of 1902 a well was drilled on a neighboring farm owned by Mrs. Huntoon. No report has been received of the result.

About the year 1888 a well was drilled on the Hovey farm in Munson township. The depth reached is reported at 1,500 feet. Some gas was

[1] *Geol. Sur. of Ohio, Vol. VII., pp.* 17-18.

PLATE VI

THE BEREA GRIT AT BEREA

found in the Ohio shales, but the quantity was of no value, and the well must be recorded with the failures.

Preparations were being made in 1902 to drill additional deep wells in the county, the objective stratum being the Jefferson gas rock, which has elsewhere been shown to belong to the Lower Helderberg.

LORAIN COUNTY.

The Berea grit forms the surface rock of the greater part of this county. Oil was discovered in the formation about 1860. The test well is said to have been drilled because of the usual surface indications. At a depth of about 65 feet a heavy oil was found, but the quantity was so small that it produced little or no excitement.

No further work is reported for 15 years, when another well was drilled on the same farm. This is said to have been a relatively large producer. The oil proved to be a good lubricator, and found a ready market in Cleveland and adjacent places. This well produced considerable excitement, some farms selling for four times their previous value. The excitement lasted two or three years, but there was some drilling as late as 1880. A few of the wells are reported to have started as high as 100 barrels per day, but the decline was rapid. Several of these wells are still pumped occasionally. Within the past few years a number of additional wells have been drilled in this territory, but the results have been disappointing. The field is commonly known as the Belden.

Near Ehart, in the southwestern corner of the county, several Berea wells have been drilled within the past few years. A small quantity of oil was found, and the wells were pumped for a short time, but the results were not commensurate with the energy and money expended.

MEDINA COUNTY.

Around the village Lodi, in the southern part of the county, a small oil field has been developed. The territory extends nearly due north and south, and has a length of about three and one-half miles, and a maximum width of about one mile. It includes parts of Harrisville and Chatham townships.

The first successful well is reported to have been drilled in 1899, on the farm of F. R. Shaw, near the south line of Chatham township. From that point holes were drilled in all directions, and at one time five strings of tools were kept busy, the field experiencing a small boom. In 1902 all was quiet, but doubtless other wells will yet be drilled.

The best wells had an initial production of from 40 to 60 barrels per day, but as in all shallow territory the decline was rapid. The oil is dark and of about 39 degrees B. gravity. In July, 1902, the number of producing wells was about 70.

The sand is the Berea, and is found in the valleys at about 260 feet. The maximum thickness reported is 110 feet. In the spring of 1901 the Buckeye Pipe Line Company laid a line connecting their tanks with the railroad, shipping the oil in tank cars; but when the Lodi refinery began work in December of the same year, the Buckeye Company removed its line.

The refinery to which reference has just been made has one still of about 250 barrels capacity. The company relies for its crude material on the wells around Lodi. There is no other supply near. During the summer of 1902 it did not use the small production of this field, and in consequence the producers were asking the Buckeye Pipe Line Company to come again to their rescue.

A well having a reported depth of 1,670 feet is said to have been drilled in the vicinity of Lodi about the year 1888. According to the information received the Berea grit was struck at approximately 260 feet and the Corniferous limestine at 1,600.

Just west of the Lodi field great depths of drift are reported. One well found 340 feet, the first formation struck having been the red Bedford shales. Such depths denote important drainage changes, the old valleys having been filled with drift during the glacial period.

A number of tests have been made in other parts of the county for oil or gas. Three deep wells are said to have been drilled in the vicinity of Medina, but all failed to secure the coveted material. The Berea has been tested at a number of places in Lafayette and Montville townships, but without favorable results. In Litchfield township, near the Lorain county line, several small gas wells have been secured. The farmers occasionally secure a supply to heat and light a residence. This territory is close to the Belden oil field, lying in Lorain county.

In the southeast corner of the county a number of wells have been drilled for salt. These are at or near Wadsworth. Doubtless the formations correspond closely with those in Summit county, records of which are given elsewhere.

CHAPTER V.

ORIGIN OF OIL AND GAS, AND THE GEOLOGICAL CONDITIONS UNDER WHICH THEY ARE FOUND.

I. ORIGIN OF OIL AND GAS.

Few questions relating to Economic Geology are more generally asked than that of the origin of oil and gas, and few are more difficult to answer. In fact it is impossible to state with certainty at the present time how these fuels have been formed. Nevertheless, because of the great interest, the subject will be reviewed here.

Petroleum and natural gas are intimately associated. Wherever oil is secured there gas also is found, and as is well known, it is the expansive force of the gas which produces flowing wells. As the gas escapes the force weakens and the well ceases flowing. Generally where natural gas is found in large quantity oil also exists, or is near. This is often well illustrated on anticlines, gas being found at or near the summit of the arch and oil farther down the slope. However, oil is not always associated with gas. Thus the great gas fields of central Ohio are not associated directly or indirectly with oil. In fact the Clinton formation has nowhere been proven to be an important producer of oil. As has already been reported in this volume, a small pool of oil has been found in the Clinton in the northern part of Vinton county and one well has been secured in this formation in Perry county, but these wells are many miles from the gas field. In the Homer field oil is still more conspicuously absent, no wells having yet been reported. Examples of a similar nature might be cited from other parts of Ohio and also from additional states, and so it may be regarded as certain that petroleum is not a necessary accompaniment of natural gas.

Considered from the chemical standpoint oil and gas are closely related, and where the oil has an unusual composition the gas of the same field is likely to be characterized in a similar manner. An illustration of this is found in the oil and gas of the Trenton limestone fields where the sulphur which is so striking a constituent of the oil is found in the gas also. In those fields where sulphur is not found in the oil it has not been reported in the gas.

From the intimate association of oil and gas in nature and from their chemical relations it seems certain that both have been derived from the

same substances and probably in the same general manner. For these reasons the two will be considered together in this chapter.

Of the theories propounded that have received serious consideration, two classes may be recognized:

First those which assign to these products an inorganic origin. These maintain that oil and gas have been produced by the reactions of inorganic substances. In general it may be stated that this class of theories has been advocated by chemists, and at the present time some eminent scholars contend that this is the most reasonable view to take of the subject. This class might be called the chemical.

The second class of theories assigns an organic origin. That is, that oil and gas have been formed in some manner from organic matter, either animal or vegetable or both. As to how the changes have been produced, however, there is much difference of opinion. While this class has been advanced by some chemists, it has been most strongly advocated by geologists, and might well be called the geological. These theories will now be considered with some detail.

THE INORGANIC OR CHEMICAL THEORIES.

While many theories have been propounded that fall in this class, a few only need be considered here. In 1866 Bertholet, a distinguished French chemist, argued that petroleum has been produced by the action of water containing carbonic acid on alkali metals deeply buried in the earth and hence highly heated. He appears to have adopted Daubree's hypothesis that the earth contains in its interior large quantities of these metals, especially sodium and potassium. He found by experiment that when carbonic acid acts on hot alkali metals, acetylides are formed, and that these bodies when treated with vapor of water produce hydrocarbons resembling petroleum.

In 1871 Byasson presented a theory maintaining that petroleum has resulted from the action on each other of water vapor, carbonic acid, sulphuretted hydrogen and hot iron. This theory also has some support from the laboratory for Byasson claims to have obtained in this manner products resembling petroleum. The vast repositories of oil found in nature, he thought, were produced by sea water containing carbonic acid or limestone in solution percolating deep into the earth and then acting on metallic iron or iron sulphide.

The inorganic theories were strengthened in 1877 by Mendelejeff, one of the most distinguished chemists of the day. He argued that the interior of the earth contains metallic carbides, that is metals, especially iron combined with carbon. Water coming in contact with these highly heated carbides would, he claimed, start reactions which would produce hydrocarbons, and convert the metals into oxides. This theory also is supported by laboratory experiments. The manufacture artificially of acetylene gas

at the present time is somewhat related to the method by which Mendelejeff thinks the great repositories of petroleum have been produced.

In the year mentioned in the last paragraph Cloez obtained hydrocarbons resembling some of the petroleum products by the action of sulphuric acid on the carbides of iron and manganese. A year later (1878) he produced a liquid resembling petroleum by the action of hot water on the carbide of manganese.

The studies of the French chemist Moissan have brought to light a large number of facts which seem to lend some support to the chemical theory of the origin of at least some of the petroleum and gas deposits. This chemist found that at very high temperatures most of the metals will combine with carbon to form substances called carbides. The most familiar one of these is calcium carbide, which is manufactured on the large scale for the production of acetylene.

As is well known, acetylene is produced from calcium carbide by the action of water upon it. Some of the other carbides produce other hydrocarbons. Thus aluminum carbide produces pure methane when acted on by water. Others produce mixtures of hydrogen, methane, ethylene, etc., and a few yield in addition liquid hydrocarbons which closely resemble petroleum. Four kilograms of uranium carbide gave 100 cc. of liquid hydrocarbons with asphalt base.

From these experiments Moissan concludes that if the interior of the earth were to contain large amounts of carbides to which water were to find its way through cracks and fissures in the earth's crust, gas and oil would result; and the large amount of heat developed in the chemical reaction would produce a substance very similar to crude petroleum. That the interior of the earth may contain such carbides, is made to appear probable from considerations that would lead too far to discuss.

These theories may suit the chemist very well, but they fall short of meeting the demands of the geologist. In general it can be said that they have been developed without due regard for the geological conditions under which oil and gas are actually found.

The theories given appear to require one element in common, namely great heat. Now this can be secured, so far as gas and oil are concerned, in only two ways, (1) by reaching great depths in the earth's interior or (2) by intrusion of molten rock. The great oil fields of this country lie in the Mississippi basin, a region that has been singularly free from intrusions of molten material. These remarks apply equally well to the recently discovered pools along the Gulf of Mexico. It follows naturally from this that the great supplies of petroleum in the United States cannot have been produced through the agency of heat derived from intrusions of highly heated material.

The other alternative, namely that the heat was obtained at great depths, is equally inadmissable. Not that high temperatures do not exist

at such places, for all admit that such are there found. However the great pools of oil and gas lie near the surface where the temperature is not more than 60 degrees above that at the surface, allowing an increase of one degree for each 50 to 60 feet of descent. In fact important pools have been found at depths of 100 feet or even less, and it is apparent to all that the temperature at such places must be little in excess of the surface average. The evidence of the absence of heat in the oil or gas-bearing rocks in earlier times is as positive as the present. Heat is one of the principal factors in metamorphism, and if any such temperatures as the inorganic theories demand had existed, the rocks themselves would furnish unmistakable evidence. In Ohio alone probably 50,000 wells have been sunk to depths approximating 1,000 feet; many have reached 1,500 feet; a smaller number 2,500 feet, and occasionally a well has exceeded 3,000 feet. Now the drillings from these are a unit in denying any evidence of high temperatures. In fact fragments brought up from the greatest depths show no more evidence of heat than do those 100 feet or less below the surface.

From these lines of testimony it is safe to say that the rocks which now contain the oil and gas have never been highly heated. There remains but one alternative for the advocates of this class of theories, and that is oil and gas were produced at great depths and have gradually risen from that place to the position which they now occupy. To this there appears to the geologist an insuperable difficulty, for lying between these deep seated and hence highly heated rocks and those which now contain oil and gas are, in many places at least, great thicknesses of compact shales and other fine grained rocks which are impervious. This is well illustrated in southeastern Ohio where the Berea grit, and of course the rocks lying above it, and which contain important quantities of oil or gas have lying below them a great mass of fine grained shales. At Lancaster their thickness is 805 feet; at Junction City 1,174, at McConnelsville 1,739 and at the Ohio river probably 3,000 feet. If the oil and gas could have risen from below, passing through this great depth of shales, they would have continued their ascent and been wasted at the surface long before man appeared. This specific example can be duplicated in some form in every great oil or gas field. Fortunately parts of the geological scale are impervious, for otherwise oil or gas in large quantities could not exist.

If the inorganic or chemical theory were true it would be reasonable to expect petroleum and natural gas in igneous rocks since they have been highly heated, and hence in a condition favorable for the production of these fuels. Experience, however, has shown that neither oil nor gas is found in rocks of this kind. So far as the writer knows there is no exception to this statement.

THE ORGANIC OR GEOLOGICAL THEORIES.

These theories have only one point in common; all assign organic matter as the origin of petroleum and natural gas. Some contend that these products have been derived wholly from animal matter, others entirely from vegetable matter, and others still from both. There is likewise no general agreement as to the method by which the change has been produced. Another point of difference still is the position which the products now have when compared to that which the organic matter once occupied. Some regard them as identical; that is, the petroleum and natural gas now occupy the same rocks that the organic matter from which the fuels in question were formed once occupied, while others contend that the organic matter originally occupied a lower position than the resultant products now do. A third view adopts each in part; that is one theory is correct when appiied to some fields but not when applied to others.

If oil and gas have been produced from organic matter then these products or others closely related ought to be secured artificially. Much experimenting has been done along this line and with considerable success. Daubree has been a pioneer in this work, and by treating wood with superheated steam obtained a product having the odor of petroleum. Warren and Storer by the distillation of a soap made from Menhaden oil obtained members of the methane, ethylene and benzene groups similar to those found in petroleum. In 1888 a more elaborate report was made by Engler who also started with Menhaden oil. By distilling this he obtained a series of oils such as are obtained by refining petroleum, and among these was an illuminating oil "indistinguishable from commercial kerosene." He later tried to secure similar results from dried animal matter such as fish, but was unsuccessful. From this he concluded that petroleum has been formed from the fats only. The agency, he thinks, was heat and pressure or the latter alone. Sadtler in 1897 announced the results of his experiments on vegetable matter. By distilling linseed oil under pressure, he obtained an oil resembling petroleum and also a scale of paraffine. It is seen from these experiments that products very closely resembling petroleum have been secured artificially from both animal and vegetable matter.

But how have these products been produced in nature from organic matter? This from the nature of the problem is not susceptible of proof. However, there is perhaps greater uniformity of opinion than in the inorganic theories.

Peckham regards petroleum to have been produced by the distillation of animal and plant remains at low temperatures. The heat, he thinks, was a result of friction produced by the elevation of the Appalachian mountains and was sufficient to metamorphose the rocks; but this applies only to the oils of such states as Pennsylvania, New York, West Virginia

and eastern Ohio, and the product in this field he considered to have been obtained from vegetable matter. Other oils, especially those found in shales in California, he classed as animal in origin. The different grades of oil found in the Appalachian field were in his judgment the result of fractional distillation, and natural gas was an incidental product. The great reservoirs in these states he thought were produced in rocks lying much below those which now contain them.

Phillips assigns a vegetable origin to petroleum, claiming that the change has taken place under water, and hence in the absence of air. The first changes were relatively rapid, and the later one, which is directly responsible for the petroleum, much slower. Apparently this theory does not require great heat.

Newberry has published an elaborate theory to explain the origin of the oil and gas in the Appalachian field. He makes the source the plant remains in the great shales lying in the Lower Carboniferous and upper Devonian formations, the products rising to the horizon where now found. That these shales contain a large quantity of organic matter has long been known. By distilling the Huron shales of Ohio from 10 to 20 gallons of oil per ton can be secured. These shales have often a great thickness and cover a very large area, and hence must contain a vast quantity of hydrocarbon compounds.

Newberry does not appear to use the term distillation in the ordinary sense. This, as is well known, requires a high temperature. Thus Engel in the work on Menhaden oil already referred to, began with a temperature of 320 degrees C. under a pressure of 10 atmospheres, and later increased the heat to 400 degrees C., at the same time decreasing the pressure to 4 atmospheres. Newberry, however, thought that the changes took place at low temperatures.

Dr. Orton has written elaborately on the subject. He considered both petroleum and natural gas to have been derived from organic matter, animals in some cases, plants in others. This could be determined, he thought, by the nature of the product; thus the petroleum and natural gas of northwestern Ohio contain sulphur and nitrogen compounds, and so have been derived from animal matter. He held the same view of the small quantity of oil derived from the Cincinnati and Utica shales in Ohio and the shale oil of California.

The oil and gas in the great Appalachian field, on the other hand, he considered of vegetable origin, making as the source plants found in the great shales underlying the oil and gas bearing formation. In Ohio these would be principally the Ohio shales (Devonian) and the Cuyahoga shales (Sub-Carboniferous). The changes were made without high temperature.

Kraemer and Spilker in 1899 announced the results of experiments on an ooze found beneath a bed of peat lying north of Berlin. The ooze has

an average thickness of about 22 feet, and the solid part consists of diatoms, desmids and higher plants. On treating this with benzol and alcohol a residue was secured which closely resembled paraffine. By treating a small quantity of the ooze with dilute hydrochloric acid, a wax was obtained which very closely resembled ozokerite. From further tests the authors concluded that the two substances—paraffine and ozokerite—have had a common origin. Previous to these results Pfitzer had discovered drops of oil in the plasma of some diatoms. These observations are of great interest because of their bearing on the origin of petroleum.

The following interesting theory has been furnished by Dr. Charles B. Morrey, Professor of Bacteriology in the Ohio State University. As will be seen it differs radically from the well known theories of Peckham, Newberry, Phillips and Orton:

"In accounting for the origin of oil and gas from organic matter, geologists have been unable to furnish the agent which might have brought about the proper decomposition, since there is no evidence of the action of heat on the vegetable and animal remains in Ohio fields at least.

"Now the only other agent with which we are acquainted which can produce the same compounds as we have in destructive distillation of organic matter are *Bacteria*. These organisms acting in the absence of air—i. e., under water—produce from vegetable matter marsh gas, olefiant gas and other hydrocarbons as well, a process frequently shown by experiment and occurring in very sluggish streams, marshes or bogs at the present time. The compounds produced here partly escape into the air and are in part retained in the mud, as a simple stirring of this shows, and there is abundant reason for believing that this same process has been going on for ages past. B. Renault has found bacteria in fossil remains of various epochs—Jurassic, Permian, Carboniferous and Devonian.

"In the formation of shales by stream deposits, wave action, and ocean currents, quantities of organic matter, largely vegetable, were deposited in the mud giving rise to such shales, and along with this material, bacteria in enormous numbers. These bacteria acting in the absence of air would form marsh gas and heavier hydrocarbons just as takes place today. This decomposition could go on not only in shallow water but also at great depths, as experiments have shown that the action of bacteria is not prevented by a water pressure of 600 atmospheres corresponding to a depth of more than 15,000 feet of water. Bacterial decomposition would continue until all the organic matter was broken up into compounds no longer capable of being attacked—the hydrocarbons among others—or until the bacteria were killed by an accumulation of their own products. In the latter case we should probably find a much higher percentage of

carbon as in coal, than we have in oil or gas. Or the decomposition could also have been stopped by a drying out of the shales—the presence of a certain amount of water being necessary for bacterial growth. Where animal remains in larger quantities were decomposed, we would have not only the hydrocarbons, but also various nitrogen and sulphur compounds exactly as we find in limestone oils.

"So that I should say that petroleum of the Pennsylvania type and gas in similar situations were formed in the mud of which shales were composed, from the time the mud was first deposited and by the decomposing action of bacteria on the organic matter therein, and the formation continued until bacterial action was stopped in the ways above mentioned.

"In the case of limestone oils and gas, the bacterial decomposition would begin with the deposit of the first dead organism, so that these substances have arisen in such localities by the action of bacteria on the soft parts of those animals whose hard parts form the limestone.

"Whether there is still undecomposed organic matter in shales, limestone, etc., experiment alone can determine; probably not, however.

"Doubtless enormous quantities of gas and oil formed in the way above described escaped into the air and were lost, and what remained was retained in various mechanical ways which it is not my province to discuss.

"My reasons for believing that oil and gas have arisen in this way may be summarized as follows:

"1. Bacteria produce just these decompositions when acting in the absence of air.

"2. Bacteria were present in the formations along with other organic matter.

"3. Bacteria are the only agents known which can produce such decompositions except heat.

"4. The action of heat (in the Ohio fields at least) is excluded by geologic evidence."

But were the fuels in question derived from organic matter which was once imbedded in the same rocks that now contain the oil and gas, or were the latter formed from organic matter which was deposited originally in rocks lying beneath those now containing these substances?

There are two different views on this matter, but the majority seems to favor the latter one. Dr. Orton regarded the oil and gas in the Trenton limestone to have been formed from animal matter which was entombed in that formation. In drilling wells in this the sand-pump sometimes brings up masses of shells showing that the rock in places is highly fossiliferous, and the same fact has long been known from the study of outcrops of the formation in southern Ohio and other states. With such

a supply of animal matter at hand, it seems altogether unnecessary to search for a source in some underlying formation.

However when the remaining oil and gas rocks are examined, the conclusions reached are not so positive. Thus the great gas wells in the central part of the state are obtained in a thin stratum of sand stone of Clinton age. Samples of this rock are not easily collected, and hence there is very little positive evidence bearing on the question as to its having contained organic matter. Lying below the gas sand are a few feet of dark colored shales concerning which we have little information. Examination of a few samples gave no evidence of an abundant fauna or flora. Below these in turn lie the Medina shales, having a thickness according to Orton ranging from 50 to 150 feet, and commonly a red color. They have been classed in the Ohio reports as generally non-fossiliferous. These could not have been the source of the great body of gas in the Clinton rock. The next formation met in descending the geological scale is the Cincinnati series consisting of shales and thin bedded limestones. These are very rich in animal remains, but the gas in question does not appear to have originated from such material, for the analysis already given shows the gas free from sulphur compounds. However, if there were not this objection we would still be confronted with a serious one—that of explaining how the gas could reach the Clinton when lying between it and the Cincinnati series are many feet of shales. It has long been the custom of geolgists to have as a condition for the occurrence of a reservoir of gas, an impervious bed lying above the rock containing the fuel in question. This is usually shale, a rock which from its fine texture seems admirably suited for the purpose. Now if a bed of shale lying above an oil or gas rock will prevent the ascent of these substances, the same kind of rock lying below will also prevent oil or gas from rising and reaching the formation which now acts as a reservoir for these fuels. Shales appear impervious, and hence oil and gas cannot have passed through them. This, of course, excludes the theory that oil and gas have been produced from rocks lying beneath those which now contain the fuels. However, where a bed of shales lies immediately below a porous rock, oil or gas might pass from the top of these shales into the overlying formation, but they could not pass from lower points in the shales into the superimposed rock. This view seems necessary but it does not simplify the main question—that of the origin of natural gas in the Clinton sand. It must be remembered, however, that if the absence of organic remains in the Clinton could be demonstrated, it would not prove that such remains never existed in the rock. Thus many of our limestones contain in places very little evidence of animal origin, the hard parts having been ground to a mud before the rock was cemented. Now if this is true of such material, it would be more

conspicuously so of plant remains, for it is of these that the Clinton gas seems to have been formed.

The same difficulty is met in attempting to explain the origin of the oil and gas in the Lower Carboniferous and Coal Measures. Take as an illustration the Berea grit. Dr. Orton says: "It is poor in fossils, but not entirely destitute of them. Fish remains are the most conspicuous, but by far the rarest of the forms it contains. Plant impressions are also unusual through most of the formations, but in northern Ohio there is a certain part of the stratum in which they are quite abundant. They sometimes accumulate in quantity, enough to be known as coal blossoms, the carbonaceous streaks that separate the sandstone beds varying in thickness from a line to a half inch."[1] This formation nearly always gives at least a show of oil or gas, and in places contains reservoirs of great importance. Lying beneath the Berea grit are the Bedford shales, having a thickness ranging from 50 to 150 feet, and according to Orton sparsely fossiliferous. Beneath these in turn are the great Ohio shales having a thickness in the eastern part of the state exceeding 2,500 feet, and being rich in organic matter. It is these that Newberry, Orton and others have regarded as the source of the oil and gas in the Berea and perhaps in the higher sands such as the Big Injun. But again the old question arises—how could oil and gas pass through the shales as was necessary before these products could reach the Berea or higher sand?

The present condition of the Ohio shales themselves bears testimony against this theory. Along the shore of Lake Erie they outcrop, and the same is true in the central portion of the state, extending from near Sandusky to the Ohio river. This condition has existed for a long time, even as reckoned by geologists. If oil and gas can rise through these rocks, they would have reached the surface and been lost ages ago. As is well known, however, such has not been the case. Along the lake shore numerous wells have been drilled and small supplies of both oil and gas have been found. A well drilled in 1895 at North Kingsville, Ashtabula county, gave the following results:[2]

	Feet.
Soil	9
Gas found at	32
Well cased at	35
Gas supply for the boiler at	60

Increased flows of gas were obtained at 76, 143, 161, 187, 221, 223, 252, 298, 312, 317 and 320 feet. Several months after completion the flow of gas was measured and found to be over 37,000 cubic feet per day. A few miles farther south another well was drilled and with similar results. Gas was found at several horizons, ranging in

[1] *Geol. Sur. of Ohio, Vol. VII., p. 29.*
[2] *Ibid, Vol. VI., p. 423.*

depth from 98 to 372 feet. Oil was found at 450 feet and at 632 feet. At Geneva gas was found at depths ranging from 130 to 1,375 feet, the strongest flow having been obtained at the latter depth. Similar results have been found at many other points. It is significant that in those parts of Ohio where the shales in question are covered by Carboniferous strata, the former do not appear to be any richer in oil or gas than where they are uncovered. This certainly would not be true unless the shales themselves are impervious.

The following extract from Dr. Orton's report expresses very clearly the quantities of organic matter which these shales now contain:[1]

"Although no great accumulations of oil are found in the shales proper, it would be wrong to infer that they are poor in petroleum. On the contrary, they contain much more than any other strata with which they are associated, the great sandstone reservoirs not excepted, but it is in a distributed condition that the petroleum occurs. The entire body of the shale carries a determinable percentage. The percentage is small, but the aggregate is vastly larger to the square mile than any square mile of the most prolific oil field that has ever yielded to the drill. Prof. N. W. Lord, chemist of the Survey, determined the petroleum existing as such in normal samples of Ohio black shale. He found the amount to be slightly less than one-fifth of one per cent., but he learned from his investigations that the finer the divisions of the shale, the larger was the percentage of oil obtained. It was therefore certain that the true percentage exceeded that reported; further than this, there had undoubtedly been some loss of the petroleum from the exposure of the shale, but even on the percentage obtained, if the shale series is counted at the low average thickness of 1,000 feet for its entire area, the total amount per square mile passes far beyond the limits of clear comprehension.

"Calculations show that it would exceed ten million barrels (10,000,000) to the square mile, and such figures stand, of course, merely for numbers that turn up in arithmetical processes, but to which we are unable to attach any definite significance further than to recognize in them very large numbers.

"The oil-stock of the shales is large, as thus appears, but the oil production is very small. The case, however, stands somewhat better with natural gas. Here again the lack of sandstone reservoirs forbids large accumulations, but the shales themselves yield gas in such volume as to become of considerable economic importance. There can be no question but that the gas is derived directly from the oil of the shales. Deep as the drill goes down the shales are found charged to the extent noted above with petroleum, which begins to break up at once into volatile compounds when exposed to the air."

[1] *Geol. Sur. of Ohio, Vol. VI., p.* 413-4.

That it is possible to have in rocks a large quantity of organic matter without direct evidence of its origin in the form of abundant fossil remains is well illustrated in these shales. Dr. Orton states:

"The shales are for the most part poor in fossils, except in those of microscopic size. Banks representing a score or more of feet in vertical column often fail to reward a careful search with a single specimen of vertebrate, molluscan or articulate life, and as far as the unaided eye is concerned, they are almost equally barren of vegetable remains. Occasionally, however, fossiliferous bands are found, the contents of which serve to determine the geological age and equivalence of the portion of the series in which they occur."[1]

II. GEOLOGICAL CONDITIONS UNDER WHICH OIL AND GAS ARE FOUND.

There are three conditions which have been strongly advocated by geologists:

1. A porous rock to contain the oil or gas.
2. An impervious cover.
3. Geological structure of the rocks which will permit the accumulation of oil and gas from relatively large areas into smaller ones.

All agree as to the necessity of a reservoir-rock. The one essential of this is porosity. Very fine grained rocks cannot, therefore, serve this purpose, and for this reason shales are not important oil or gas containing rocks. In Ohio three types are found—limestones, sandstones and conglomerates. The limestones have been elaborately described by Orton. As has already been stated, they contain the immense repositories in the northwestern part of the state, but are not productive in other fields in Ohio. Analyses show the rocks to be strongly magnesian and Orton placed much weight on this feature, since limestones of this type are notably porous when compared with those of the ordinary or calcareous type.

Recent developments in Texas, however, show that calcareous limestones may serve as a reservoir for oil. Thus according to an analysis made by Worrell, the oil rock in the great Beaumont field contains over 97 per cent. carbonate of lime. When it is considered that this rock has yielded by far the greatest wells yet drilled in the United States, it is ap parent that ordinary limestone may serve as efficiently as that of the magnesian type.

Sandstone is the most common reservoir rock, and perhaps the Berea grit is the best illustration of this. The rock is composed of moderate sized grains of silica. However, it appears compact, and the quantity of oil which it contains often seems out of proportion to the porosity of the rock. In fact it is hard to believe that this formation ever contained the

[1] *Geol. Sur. of Ohio, Vol. VII., p. 24.*

great volume of oil that has been taken from it in places,, as for illustration the Scio field. This appears all the more remarkable when it is recalled that the so-called pay-streak usually composes a small part only of the rock. Sands of this character do not yield great wells, but their life as a rule is long. These characters are certainly in harmony with the porosity of the rocks. The Berea is the finest grained of the important oil or gas sands of the state.

Sandstones grade imperceptibly into conglomerates, and hence it is not easy to say when one leaves off and the other begins. Many of the so-called conglomerates of Ohio vary in texture rapidly, changing in a short distance to a sandstone. The Big Injun, Keener, Macksburg 500-foot, and First Cow Run sands are conglomeritic in places, but more commonly they are coarse sandstones. They make excellent reservoir rocks, and the wells sometimes have large initial productions. The decline, however, is almost invariably more rapid than in the Berea. The production is often long maintained, as is illustrated by wells at Joy, Cow Run and other places.

Shales are not important sources of either oil or gas though small quantities of both are often found in them. In the coarser grades of these rocks oil and gas may occupy the spaces between grains, but in the finer grades the fuels in question probably lie between the layers of the rock rather than between the component particles.

The necessity of an impervious cover is apparent. Without it the gas would have risen to the surface and been lost ages ago, and the more volatile parts at least of the oil would have met a similar fate. Not uncommonly the rock is very compact at the top forming the "cap" of the driller. This may serve to retain the oil and gas below. Generally, however, a bed of shales lies above the formation, and serves to prevent the ascent of the fluids. A thin bed of fine clay also would serve admirably to seal in the oil and gas.

The third geological condition is structural, and is commonly known as the anticline or terrace. This permits the oil and gas of a relatively large area to accumulate in a much smaller one. This theory has been strongly urged by White and Orton, and in a more general way by others at an earlier date. It is very generally accepted by geologists and almost equally so by laymen. In many cases important reservoirs have been located by applying the principle. Thus in eastern Ohio Orton predicted the presence of oil in the Moore's Junction field west of Marietta, and correctly located the Snyder and Bricker pools in Harrison county. White has been still more successful in West Virginia and Pennsylvania. Among other pools in eastern Ohio that have been demonstrated to lie on anticlinals may be mentioned Macksburg, Cow Run, Newell's Run and Sistersville. In the northwestern part of our state the rocks form a broad arch, dipping to the northwest on one side and to the southeast on the other.

This is readily seen by examining a geological map. The arch contains minor irregularities, such as the well known Findlay break described by Orton and mentioned in the discussion of Hancock and Wood counties in the earlier parts of this volume. It was on or near this break that many of the largest gas wells were found, and in general it may be stated that the richest oil territory has been found where the Trenton rock lies highest.

In the southwestern part of the Trenton field, in Mercer, Auglaize and Shelby counties the rock in question rises to the south and is exposed in the bed of the Ohio river at Cincinnati. This seems to exclude the idea of an arch in that part of the field. From Mercer county north the dip in the Trenton rock is small, the structure being more of a terrace than an anticline.

It cannot be said that all oil or gas fields in Ohio are associated with anticlines or terraces. Thus the great gas field at Sugar Grove, the oil fields at Chester Hill, Corning, Scio and several smaller reservoirs have not as yet been demonstrated to lie on these structures. However, the reverse has not been conclusively demonstrated, and the fields in question may still fall in with the anticline or terrace theory. The great reservoir at Beaumont, Texas, also appears to stand in opposition to this theory.

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